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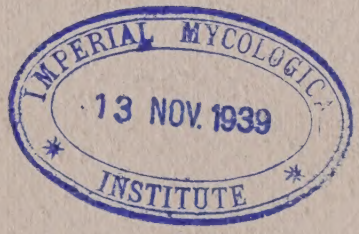


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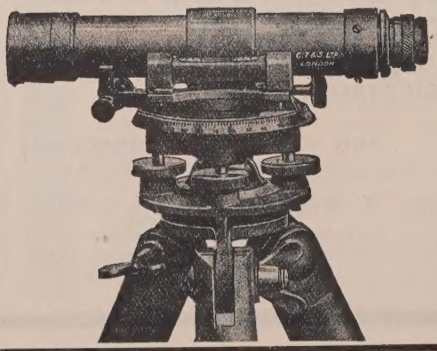


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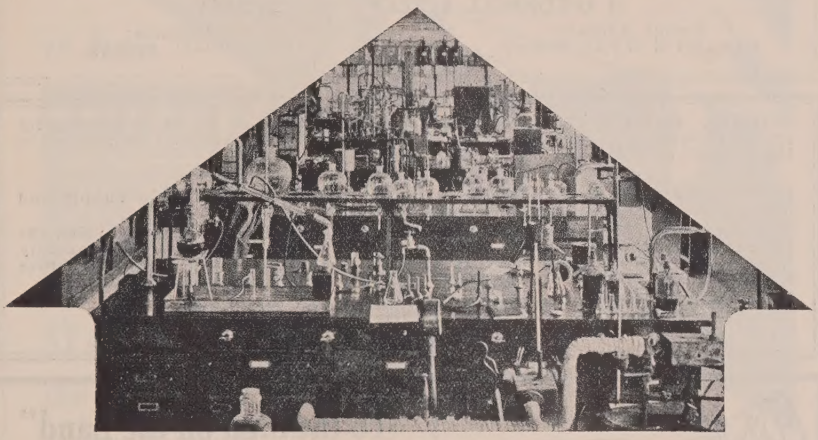

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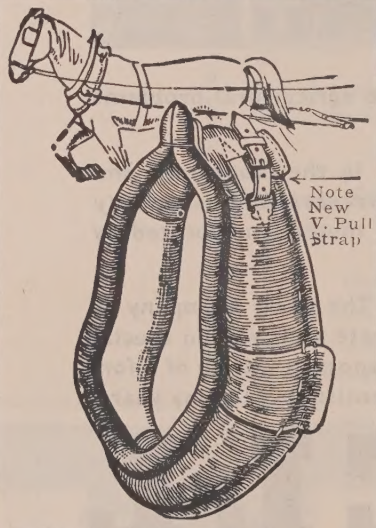


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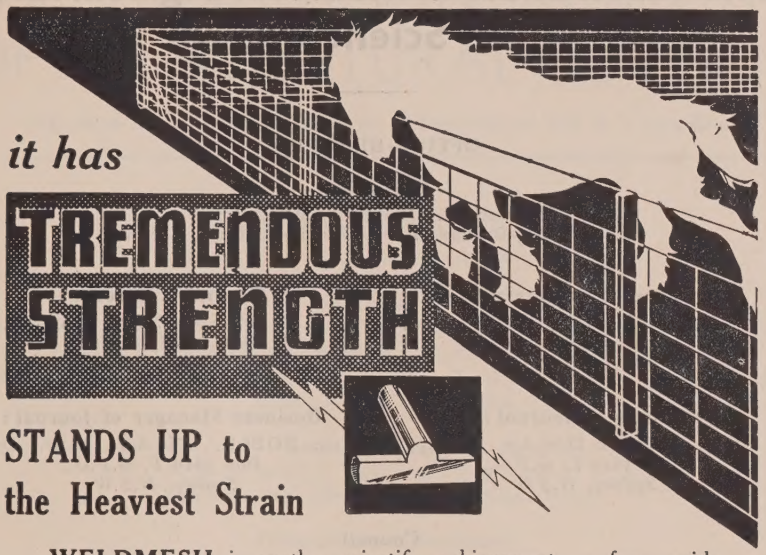

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VOL. 5, No. 3 SEPTEMBER, 1939

## In Defence of Liberty and Justice

The 1st of September, 1939, will go down in history as the day when Adolf Hitler, the untrusted German Chancellor, wantonly launched his naked and brutal attack on Poland as the means of settling his territorial claims in that region. That in this he showed complete disregard for all peaceful and humane methods of deciding international issues, and ruthlessly swept aside his solemn pledge for settlement of disputes by consultation, is the unqualified testimony of the nations today ; and it was with the clearest conscience that Great Britain and France were finally faced with the only alternative of declaring, on the 3rd September, that they were then at war with Germany. The long struggle for peace has ended, and it will be to the lasting credit of the British Prime Minister (Mr. Chamberlain) that this fateful decision was

not reached until every avenue of approach towards a peaceful and negotiable settlement of the difficulties had been fully explored. The outcome of the conferences with Hitler over the Sudetenland last September seemed at the time satisfactory—the more so as this was definitely stated by him to be Germany's last territorial claim in Europe. But now the world knows to its sorrow that the Fuehrer's absorption by force and blackmail of Bohemia, Slovakia and Memel only six months later, and his present atrocious aggression on the Polish people are the clearest evidence that the policy of subjugation by force has been his neurotic dream and ambition since Nazism gained ascendancy. Hitler plainly wanted war, and he alone is responsible for the trickery and lies which have culminated in the betrayal of his 80,000,000 subjects to this wicked and unprovoked aggression, involving as it does so many countries to whom war is a horror and an abomination. Never has the brand of guilt for war been so clearly and centrally placed as it has been on Hitler and his blood-thirsty supporters. The die has been cast, and the challenge will be met by the united strength of Great Britain and France in the firm belief that the forces of oppression and persecution will be subjugated. Possibly the German people have been gulled by the sickening technique of Nazi propaganda into believing that their cause is a just one, but time will tell whether that country is as united as the Fuehrer would have the world believe. Culture, religion and intellectual freedom have long since been swept aside in Germany as part of the scheme which has become so insatiable and soul-destroying in the eyes of the Democracies; and the present struggle will be fought in the knowledge that Britain and France have had time to prepare morally and materially for the attack they will now make with unremitting efforts against the principle which, if unchecked, will certainly continue to threaten the safety and freedom of Western civilisation.

The broadcast speeches of the British Prime Minister and of our Australian Prime Minister on the eve of Britain's declaration of a state of war, will long be remembered for the restrained and confident tones with which the fateful words were conveyed to the world. The struggle may be long and bitter, but in these dark and solemn days we as Australians and as members of the British Commonwealth of Nations will take our place, calmly and courageously, in the spirit that "liberty and justice will prevail".

# The Challenge to Wool

The public meeting arranged last month by the Victorian Branch of the Institute was important for the reason that attention was again focussed on the threatening effect of artificial fibres in Australia's national economy. It is platitudinous to aver that the mainspring of this country's development has been the expansion of woolgrowing, and that in value of output wool is still the largest single industry and contributes the largest individual item in the export trade (40 per cent.) of the Commonwealth. Australia grows 28 per cent. of the total weight of wool produced in the world, 50 per cent. of the world's production of fine merino wool and 38 per cent. of all wool entering world trade. These figures are eloquent of the enormous extent to which our national economy is dependent on the demand for wool, and any shift of a permanent character in this demand must of necessity occasion anxiety. There is ample evidence that in their desire for self-sufficiency, totalitarian countries have placed definite limits on wool imports; hence the awakening in other countries as to the threat constituted by the increased use of staple fibres, and the price competition thus involved. At the moment there is no over-production of wool, and nothing has yet been developed to submerge wool from its pinnacle position as a hygienic and healthful clothing—this despite its drawbacks of shrinkage and tickle. But very notable advances have been made in the development and improvement of substitutes, and the advances that doubtless yet will be made must result in an even greater downward pressure on the price of wool. The consequences are that wool interests have been forced to take stock of ways and means of meeting the threatened competition which has been so apparent during the past ten years. Although artificial fibres have, and certainly will continue, to embarrass the supremacy long enjoyed by wool, the position has also been aggravated in other respects: trade diversion policies, world-wide shift from worsted to other fabrics, more general adoption of lighter clothing, central heating, and the capriciousness of fashion.

The efficient and low-cost methods of producing artificial fibres, together with the satisfactory system of effecting their proper distribution and use, have not made easy the path of either the producer or manufacturer of wool. The palmy days have gone, and while the manufacturer may be consoled in the knowledge that he can substitute staple fibre for wool whenever it pays him to do so, and that fibre mixtures can easily be processed on standard woollen machinery, the producer on the other hand cannot be so easily consoled. Wool returns are falling and production costs have risen, and unless there be a satisfactory price for wool in world markets and a commensurate reduction of costs in production, the position is likely to be even more fluctuating and

precarious than it has been during the past twenty years. The present indications certainly do not point to imminent collapse, but how is the long distance effect to be met? There is real need for increased efficiency both from within and without the wool industry. Research and publicity will play a useful part, but the exploration of new and undeveloped markets is more urgent still. If world trade were free from the restrictions now impeding it, and there were just faint signs of a return to world prosperity, the wool industry could face the future with optimism; but the announcement this month of the British Government's decision to buy the whole of Australia's wool clip during the war now in operation will bring a measure of financial stability to the Commonwealth at a time when the primary industries are in the doldrums.

---

# Can Wool Hold its Place in the Textile World?*

## PART 1.—THE ECONOMIC IMPORTANCE OF WOOL

By

Sir Dalziel Kelly,

*Chairman of the Australian Wool Board.*

Wool is the second largest item of world trade, being second only to cotton.

The sheep and wool industry in Australia has had a remarkable growth. In 1788, this country carried 29 sheep, while some 100 years later (1891) there were approximately 100,000,000 sheep. The 1938 figure was 114,000,000. Even after allowance for the severe losses of the past drought, the present total is probably about 110,000,000. There are more than 80,000 woolgrowers in Australia, 60,000 of whom have fewer than 1,000 sheep. The annual production of wool is 3,000,000 bales, valued at approximately £45,000,000.

The world trade in wool is of great importance to the British Empire, which produces 70 per cent. of the world's trade wool or 80 per cent. of the fine wool. Britain's dominant position in the wool trade is the underlying reason for the strenuous efforts of foreign countries to develop artificial fibres.

The wool industry of Australia cannot be said to be in a prosperous condition. The cost of production is not less than 1s. a lb. The average price

* Summaries of addresses delivered at a public meeting arranged by the Victorian Branch of the Institute at Melbourne University on 1st August, 1939.

last season was 10·66d. The average for the past ten years was 12·3d., and that for the past five, 13d.

One of the major difficulties of the industry is the over-capitalisation of land. Growers have been paying £6 to £7 a sheep-area for land, the productive value of which is not greater than £4 to £5.

### Restriction of Markets.

Restriction of markets has added to woolgrowers' problems in recent years. This has taken two forms: a curtailment of purchases by countries such as Germany, Italy, Japan and China; and the inroads of artificial fibres upon what were previously the preserves of wool. Prior to the "incident" in the East, China was a rapidly developing market for Australian wool. Exports to China have risen from less than 500,000 lb. in 1930 to 13,500,000 lb. in 1936-37.

Germany was formerly a large buyer of Australian wool and would be still, if able to purchase here, but that market has been largely restricted. Italy is still a fairly large buyer, but not so great as previously.

The use of substitutes is developing rapidly on the Continent. German legislation requires manufacturers to adulterate wool to the extent of 25 per cent.; but the superiority of wool is tacitly admitted by the stipulation that all naval uniforms and export goods must be made of wool only. The adulteration of fabrics for military uniforms is limited to 10 per cent.

An important outlet for wool was lost with the advent of artificial silk stockings, which appealed to women because of their lightness and sheer. Efforts are being made to regain this market. Woollen stockings as light and as sheer as silk are now being produced. Woollen underwear as light as silk is another bid to regain a lost market.

Woolgrowers obviously need a higher price or a reduction in costs to restore prosperity. There is little scope for improvement in marketing. The industry has a well-organised system which has stood the test of the depression and which is the envy of other branches of primary production. The Australian Woolgrowers' Council, which speaks for the industry, is opposed to any price-fixing scheme on the grounds that such schemes have failed in every other industry in which they have been tried.

### Wool Bounty.

Although the industry has always fought against any government intervention, the severity of present conditions has compelled it to apply to the Federal Government for a bounty on wool. The justification for such assistance is the increase in woolgrowers' costs as the result of protection to secondary industries. The woolgrower concedes that protection might be desirable to

secondary industries during the developmental stages, but considers that he should be compensated for the reaction upon him.

Some years back, the wool industry realised that its salvation lay in research and publicity. To that end a compulsory levy of 6d. a bale—which no grower really felt and which yielded £70,000 a year—was imposed. This fund is administered by the Australian Wool Board. Expenditure is restricted by law to the two abovenamed objectives.

Publicity involves more than the publication of placards inviting people to wear more wool. It extends to the development of new outlets. Much of this work is being organised overseas by the International Wool Secretariat, supported by the wool exporting countries. Australia is represented on that body by Dr. Clunies Ross, an officer previously on the staff of the C.S.I.R.

The Wool Board has recently initiated a publicity campaign in Australia. Retailers have responded well, but manufacturers sat back at the beginning. The fact that the latter have since come forward with contributions is surely a compliment from the hard-headed business world.

## Research.

Research at Torridon (Eng.) and in Australia is being financed by the Board. Up to June 30th, £44,000 had been spent on investigational work, with "some" results. It is realised that immediate results should not be expected. Research is necessarily slow but there is no doubt that it will bring further positive results in reducing the costs of production of both wool and woollen goods.

Although the industry is in difficulties, it is not bankrupt. Australia's economy is founded upon primary products, and the chief of these is wool. Many individuals might fail, but the industry will continue. There is no doubt that wool will retain its place in the textile world.

One point of particular interest is that there is certainly no over-production of wool. In the past twenty years the world production of wool has not increased by more than 1 per cent. This is less than corresponding population increase. If wool could be sold during the past year of international tension, it can certainly be sold without difficulty if more peaceful conditions prevailed.

# PART 2.—PROPERTIES OF WOOL FIBRE AND WOOL SUBSTITUTES

By

MARTIN R. FRENEY, B.Sc.,
*McMaster Animal Health Laboratory, Sydney.*

It is proposed at the outset to deal with the primary characteristics of wool, or those on which all others depend. A summary of these characteristics is given in Table 1.

## Primary Characteristics of the Wool Fibre.

The first is cellular structure, on which many of wool's physical characteristics, such as strength and elasticity, naturally depend. The wool fibre is a solid rod (Fig. 1A) of spindle-shaped cells surrounded by a layer of overlapping cells which are commonly known as the scales. These all point towards the tip, and are illustrated in Fig. 4A.

In kemp, there is in the centre of the fibre (Fig. 1B) a structure known as the medulla. This consists of loosely packed, thin-walled cells and the air in the medulla gives kemp its glistening appearance. It is a mistake to regard the kemp fibres as hollow, for the medulla really resembles the pith of a reed. Human hair consists almost entirely of medulla (Fig. 1C).

The second property is length, which varies with the individual sheep as well as with the breed or type, and naturally depends also on the interval between shearings. South Africa produces many shorter Merino wools than Australia, and this is due to the fact that whilst we shear at yearly intervals, the graziers in the Union often shear after 8 to 10 months. A year's growth, or staple, of Merino wool varies from 2 to 5 inches in length and, if stretched to eliminate crimp, the fibres in these would be 3 to $7\frac{1}{2}$ inches long, respectively. If a Merino sheep be well fed and not shorn, its fleece will not be shed and it will grow indefinitely. A sound fleece with a staple 17 inches long, representing six year's growth of sound wool, has been produced in this way in South Africa.

The third characteristic is fibre thickness or cross sectional area. The thickness of the wool fibre is of definite commercial importance, for, other things being equal, finer Merino wools bring better prices on a scoured weight basis than coarser ones.

In scientific experiments, fibre thickness has been estimated by the tedious method of measuring many fibres. Hence we hear of " fibre diameter ", but a glance at the cross-sectional shape of wool fibres—such as are shown in Fig. 1A—should convince anyone that there is so much irregularity that an

TABLE 1.—*Showing how the Properties of the Wool Fibre are concerned in Manufacturing Processes.*

| PROPERTY. | FIBRE. | | | | | | | YARN AND FABRIC. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Blending. | Scouring. | Drying. | Carding. | Combing. | Felting. | Drawing and Spinning. | Dyeing. | Weaving or Knitting. | Finishing. |
| Cellular structure | | | | | | | | + (Kemp) | | |
| Length | + | | | + | + | | + | | | + |
| Fineness | + | | | | | + | + | | | |
| Strength | + | | | + | + | + | + | | + | + |
| Crimp | + | | | | | + | + | | | |
| Surface structure | | | | | | + | + | | | + |
| Elasticity (stretchability) | | | | + | + | + | + | | + | + |
| Chemical composition | | + | + | | | + | | + | | + |
| Physical structure | | | + | | | | | + | | |

Plus sign indicates that the characteristic is important in the various processes listed.

TABLE 2.—*Showing how some Properties of Marketed Wool Fabrics depend on Fibre Characteristics.*

| PROPERTY OF FIBRE. | ADVANTAGES. | | | | | | | DISADVANTAGES. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PROPERTY OF FABRIC. | | | | | | | | | | | |
| | Strong. | Soft. | Durable. | Resilient, Stretches and Sets. | Absorbs Water. | Warm. | Healthy. | Safe (does not Melt or Burn). | Shrinks through Relaxation. | Shrinks through Felting. | Dries Slowly. | Attacked by Moths. | Prickly. |
| Cellular structure | | | | | | | | | | | | | + |
| Length | + | | | | | | | | | + | | | + |
| Fineness | | + | | | | | | | | + | | | |
| Strength | + | | + | | | | | | | + | | | |
| Crimp | | + | + | + | | + | + | | | + | | | |
| Surface structure | | + | | | | | | | | | | | + |
| Elasticity (stretchability) | + | | | + | | | | | + | | | | |
| Chemical composition | | | + | + | | | + | + | + | + | + | + | |
| Physical structure | | | | | + | | + | | | | + | | |

Plus sign indicates that the property of the fibre under consideration plays an important part in giving the fabric its peculiar properties.

*average* fibre diameter can mean little unless both the variation from that diameter, and the ellipticity of the fibres, are measured. The illustration in Fig. 1A is rather typical of a fine well-bred wool, and the big variation in fibre diameter or thickness in any one wool sample is clearly shown.

The fourth characteristic is strength, and a study of this is being carried out at the McMaster Laboratory. To judge the strength of wool fibre by estimating the weight that is necessary to break it, is to tell only part of the story. We have found that if the parts of a broken fibre are again tested, the weight under which they break is higher than that at which the original break occurred. In other words a fibre, like a chain, breaks at its weakest point. If a *thread* composed of a number of wool fibres is subjected to stress, it is probable that the stress will not fall on the weak points of *every* fibre. Such a thread will carry a load greater than if each fibre in it were uniformly as weak as its weakest point. This must be remembered whenever the strength of wool is being discussed.

The next, or fifth, property is crimp or wave in the wool, which confers definite advantages upon wool as a textile fibre. Crimp is a permanent feature of the fibre and it is very difficult to remove. Practical men consider that the finer wools are those with the most crimp and that this is a useful guide to

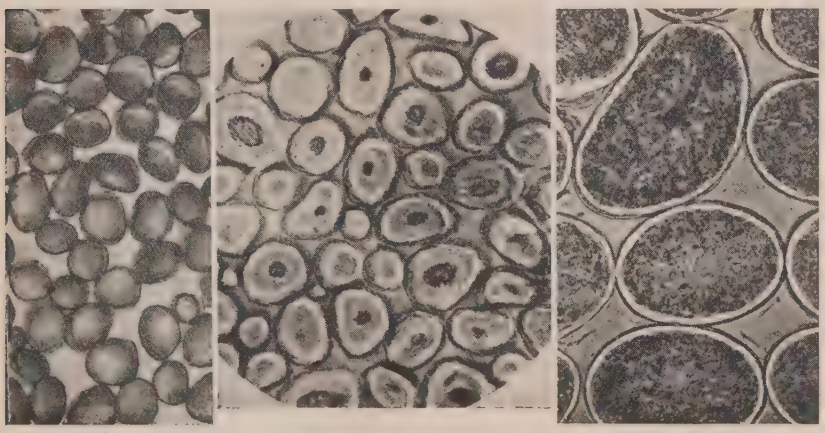


*Figure* 1.—*Cross Sections of some Natural Fibres.*

A. Cross section of Merino wool fibres. The dark outer band is the cuticle, and the whole structure inside this is the cortex. This plate shows that few fibres are really circular. (Hardy.)

B. Cross section of fibres from cross-bred sheep. Cuticle and cortex can be seen, and the centre of some of the fibres—the kemp fibres—is a dark mass, which is the medulla. (Hardy.)

C. Cross section of human hair. The medulla which shows up darkly, occupies most of the fibre. Outside this the cortex shows as a light band, and the cuticle shows up as a dark outer band. (Hardy.)

quality. Because it is crimped, the unstretched wool fibre appears about two-thirds as long as when all the crimps are straightened out by tension.

Sixth on our list is the surface structure of wool. It has been pointed out already that the fibre is covered with scales which overlap like those on a fish. Although hair and animal furs also have scales, those on wool are so characteristic that they may be used to identify it. By drawing the wool fibres through the fingers one can determine fairly easily the direction in which the scales point.

That woollen goods are elastic is obvious, and this is the seventh property of the fibre. Here we must differentiate between elasticity in its scientific and practical senses. Stretchable is perhaps a better term than elasticity in dealing with wool. In water or steam a wool fibre can stretch to about twice its length without breaking, and if it is dried in this stretched state under tension, it will remain stretched when the tension is removed ; it will, however, return to its original length when wetted. This is important from the practical point of view.

The eighth property of the wool fibre is its chemical composition. Like silk, wool is a protein and the wool protein is termed keratin. Being a protein, wool is composed of chains of amino acids, each of which contains a basic amino group and an acid carboxylic group. Protein chains are formed by the union of these groups from different amino acid molecules by a type of linkage known as a peptide linkage. Wool is outstanding amongst the textile fibres for the large amount of sulphur it contains. Our knowledge of the molecular structure of wool is very limited. However, the free basic radicle content of wool allows it to combine loosely with acidic substances.

Physical structure is the ninth and last of wool's primary properties. The term physical structure indicates not the cellular structure, but the ultra-microscopic structure of the fibre resulting from its chemical composition and molecular structure. Our conception of the physical structure of wool, though founded on hypothesis, is indirectly based on certain accurate measurements of the chemical behaviour of wool in acids and its physical characteristics when immersed in organic solvents. The keratin material which fills the cells of the fibre is considered to be composed of innumerable individual plates, termed micelles, pressed together like a pack of cards. As a result of this structure, wool has a very large internal surface area ; it has been estimated, for instance, that this area in one ounce of wool is about one-quarter of an acre. Wool's adsorption phenomena, such as the power to take up water, depend upon these large surface areas, which are therefore of considerable practical importance.

This list of properties is not exhaustive. Wool has other properties such as refractive index, specific gravity and specific heat. But the nine properties I have mentioned seem to me to be those of outstanding importance. Table 1 indicates how each of these properties is concerned in the various wool manufacturing processes.

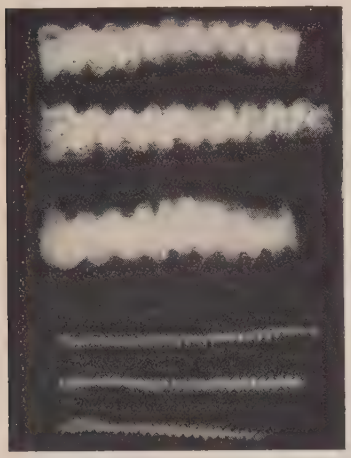


*Figure 2.—Relationship of Crimp and Fibre Fineness.*

Merino wools from the shoulder whose fibre thickness is approximately the same, but whose crimps differ greatly.

A. Fibre diameter, 22·5 M. Crimps per inch, 7.

B. Fibre diameter, 23·7 M. Crimps per inch, 18. (Swart.)

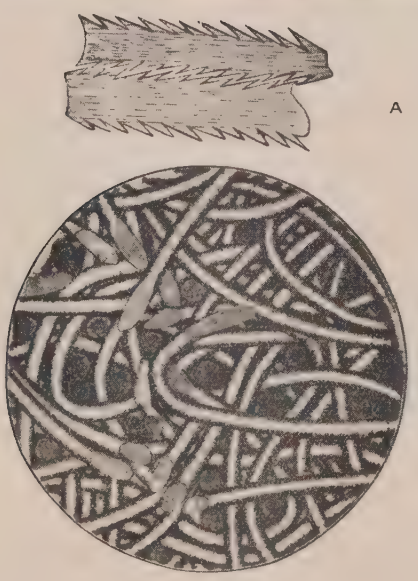


*Figure 3.—Felting of Wool.*

A. Diagrammatic illustration of interlocking of scales on adjacent wool fibres. This, according to one theory, is the cause of felting. (Matthews.)

B. Photograph of a felted fabric showing fibres twisted and intertwined and few lying parallel to one another. No evidence of scale interlocking on a large scale. (Matthews.)

## Manufacture and Properties of Wool Substitutes.

And now we must briefly consider the wool substitutes and their development in different countries. The advance of economic nationalism has certainly stimulated the production of artificial wool, but we must bear in mind that the non-totalitarian countries have also contributed greatly to the technical development and exploitation of wool substitutes.

The progress in the development of wool substitutes must bring pride to the heart of any chemist, for the chemistry of wool is complex enough to daunt the bravest. By now, over 160 varieties of artificial fibres have been registered in Germany, so I will not attempt to describe them individually but will limit myself to the three main classes :

(1) *The Cellulose Fibres.*

These fibres are made from wood by the pyroxylin process, the cuprammonium process and the viscose process, and they are manufactured extensively in England, America, Japan, Italy and Germany. As about 90 per cent. of the world's production of artificial fibres is made by the viscose process, I will describe it in some detail.

Purified cellulose from spruce or beechwood is treated with caustic soda which is then squeezed out by an hydraulic press, and the cellulose is dried. It is then dissolved in a solution of caustic soda and carbon bisulphide, and the solution of cellulose xanthate which results is known as viscose. This is purified and is forced through fine orifices called spinnerets into a precipitating bath of sulphuric acid and ammonium sulphate. This converts the viscose to fibres of cellulose, which are then dried. If the fibres are dehydrated in alcohol, they handle more softly than if they are dried by heat. Fig 4A shows a viscose cellulose fibre from Germany.

(2) *The Protein Fibre.*

The raw materials from which the protein fibres are made are casein (Italy), soya bean protein (Japan), and fish albumen (Germany). Wool, we have seen, is a protein fibre and it is this fact which stimulates the manufacture of artificial protein fibres. The method by which one of these, " Lanital ", is made is to purify casein from milk and dissolve it in a caustic soda solution containing a little carbon bisulphide. A small amount of ammonia is added to this mixture to improve the spinning. The solution is passed through spinnerets, into a bath of sulphuric acid and ammonium sulphate and the filament which forms in this is hardened in a solution of formalin. A protein fibre made in Holland is shown in Fig. 4B.

(3) *Synthetic Fibres.*

These may be made from vinyl resins, methacrylic resins or polyethylene resins, all of which are types of heat-softening plastics. They are prepared from raw materials such as coal, oil and even coal gas, and their value as textiles has not yet been fully investigated. The most important synthetic fibre is one termed Nylon, which has been recently developed in America (Fig. 4C). It is similar in type to a protein fibre, and the raw materials from which it is made are coal, air and water. Its sponsors, who are some of the strongest financial interests in America and England, propose to produce this material

as a substitute for silk, to which it is superior in many respects, and it is not yet being produced as a wool substitute. It must be remembered, however, that silk is a protein fibre and any threat to silk may ultimately become a threat to wool.

Any of these processes can be used to make a straight, continuous filament, whose fineness is comparable to that of wool, but which can be more even than wool. A staple fibre more uniform in length than wool itself is produced by cutting this fibre to any required length. As to strength, only the new synthetic

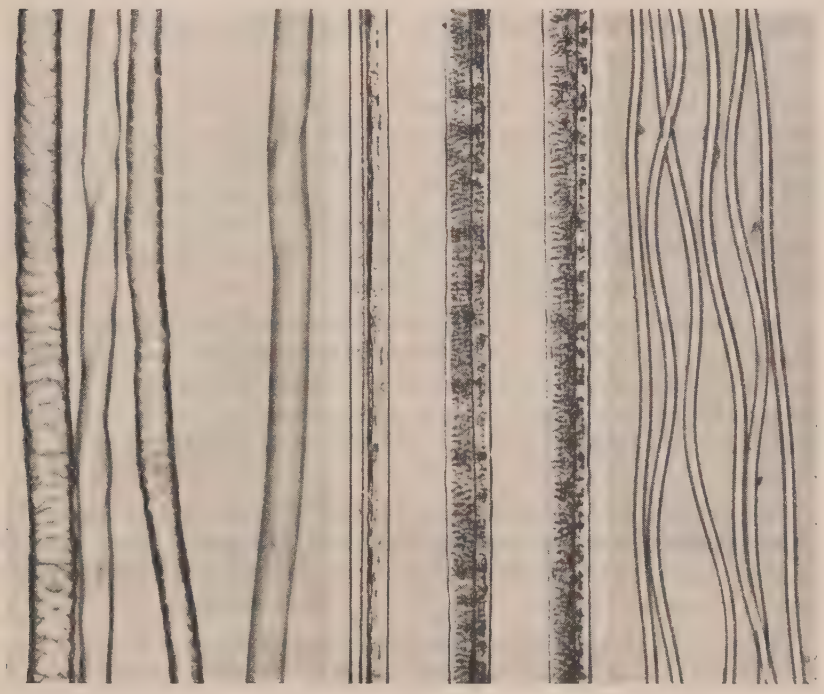


*Figure 4.—Wool and Artificial Fibres.*

A. Two wool fibres can be seen, and the scale structure of their surfaces is clearly visible. The other two fibres are Vistra, which are cellulose fibres made from wood in Germany. Note the smooth surface structure.

B. Lanital, a protein fibre made from milk casein. The fibres—three are shown—which were made in Holland, have a rough surface and are said to felt.

C. Synthetic fibres, made from coal, air and water, in America. These six Nylon fibres have a smooth surface and are finely crimped.

fibres are comparable with wool, the protein fibres and the cellulose fibres being inferior in this respect. Whilst the strength of the wool fibre is not just the strength of its weakest spot (the rest of the fibre may be considerably stronger) each artificial fibre is fairly even in strength along its length. Woollen *threads* would therefore be stronger than *threads* made of artificial fibres whose strength throughout was equal to the original breaking strength of wool. Crimp may be impressed on the cellulose or the protein fibres by using rollers, or by currents of liquid, in the precipitating baths. A more difficult method is to impregnate or coat the fibre with a urea formaldehyde resin which is moulded to a crimped form with hot rollers. Such crimps are not permanent and tend to come out during wear, but those impressed on the true synthetic fibres may last longer.

The stretchability of the artificial fibres does not approach that of wool, but there is no telling what progress will be made in this field with the truly synthetic fibres. The cellulose fibres, and those made from proteins, seem to be out of the hunt in this respect, and also as regards elasticity in its scientific sense. But the truly synthetic fibres of the Nylon type are, like real silk, extraordinarily elastic in the sense that they can recover their original form after being under relatively great tension. Of course this does not mean that they must stretch greatly under this tension.

In chemical composition, the protein fibres most closely resemble wool but they are not as stable. One of their advantages over the pure cellulose fibres is that they dye like wool, and so their mixtures with wool will absorb the usual wool dyes. However, with a certain amount of expense, the cellulose fibres can be impregnated or coated with a basic resin material which dyes like wool.

Some of the truly synthetic fibres, like Nylon, have a molecular structure remarkably like that of wool and they, too, are said to dye like wool. Because the physical structure of wool is much more complex than that of the artificial fibres, it is superior to them in its ability to absorb moisture.

Attempts have been made to imprint scales on artificial fibres, but the scales on wool have not yet been closely imitated. We do not know, however, whether the scales are the cause of felting (*vide* Fig. 3, A and B) or whether they confer beneficial characteristics on wool for manufacturing or wearing purposes. If they do, then the manufacturers of artificial fibres still have a difficult task before them. Some of the artificial fibres have a pitted and roughened surface, as can be seen from Fig. 4, B.

It will be seen from what I have said that the synthetic fibres differ greatly from wool. Wool's position, clearly stated, is that it is stronger and more stable than all but Nylon, and some other true synthetic fibres. As a consequence, it will wear longer and give greater service. It absorbs moisture and becomes warm in doing so, without becoming clammy. Wool is naturally

warm due to its crimp, and in this respect it is superior to artificial fibres. It can be made to felt in manufacture, but sometimes this felting causes inconvenient shrinkage. Fabrics made from wool are elastic and may be pressed and set to a neat, smooth shape. Concerning ability to retain their finish during wear, those woollen fabrics which are not generally washed are greatly superior to fabrics made from artificial fibres. With those that are washed, however, an attractive finish is sometimes a disadvantage for the nice shape when purchased disappears as soon as the garment is immersed in water, and it goes baggy and shrinks through relaxation. Finally, wool does not burn or melt. Even an 85 per cent. wool and 15 per cent. viscose mixture burns very much more readily than wool itself.

## Research on Wool.

What can be done to keep wool to the fore ? Firstly, we must remove its inherent disadvantages, i.e. its liability to moth attack and its prickliness. Then we must learn how to control its circumstantial disadvantages, such as its shrinkage through relaxation and shrinkage through felting and its slow drying. We must also cheapen methods of manufacture and lower production costs. This all involves investigations of fundamental and practical importance, and no avenue by which wool can be kept ahead of its competitors should be left unexplored. A brief survey of the problems that need to be investigated and of the research work which is going on may be of interest.

One of the most urgent problems, which is still unsolved and which has been an outstanding difficulty, is to get a clear and accurate definition of those characters which determine wool quality for manufacturing purposes. Crimp alone is not a satisfactory criterion of wool quality, as can be seen from Fig. 2. Work is still going on wherever wool is being investigated to define quality, and the findings will be passed on to the grazier to help him to improve his product for the manufacturer.

An increasing amount of research on wool is going on in many countries. X-ray studies to determine its molecular structure are being carried out in England, America and Germany. In many centres wool is being examined in great detail under the microscope by normal and polarised light to determine the effect of different manufacturing and chemical treatments upon it. The tendency to shrink through felting is receiving much attention, and methods by which wool may be made non-shrinking have been developed by the use of chlorine in one form or another, and are still being investigated. Much research is being carried out to determine the cause of shrinkage and felting, to see whether it is due to gelatinisation or to scale interlocking or to some other factor.

Methods by which the dyeing of wool might be cheapened, how it might be made mothproof in a cheap and simple manner, and how the prickly feeling

might be eliminated are being investigated in many countries. The undesirable static electric charges which develop during processing add to the cost of manufacture, and so might well repay investigation. In Australia, our main objects have been to show how wool can be produced at a lower and more competitive price.

And now, having surveyed the field in detail, one comes to the main question of the lecture " Can wool hold its place in the textile world ? " We must all admit that the wool substitutes have progressed greatly and have invaded fields which custom has reserved for wool. Despite their advance, it would be foolish to overemphasise their threat, but it would be more foolish to underestimate it. In my opinion, wool still has a great lead over its competitors, though the pace at which the latter are advancing is quickening. To keep wool ahead, we must increase our knowledge of it and apply any useful knowledge as quickly as possible.

I can foresee that within ten years substitutes will be produced not as cheaply as wool, but with virtues similar to those of the natural product. It is for this reason that great scientific effort is necessary to keep wool ahead and the graziers of Australia are, through their Wool Board, adopting a far-sighted policy in supporting much scientific work on all phases of wool production and consumption.

Personally, I think that some of this work will have to be intensified, for it is becoming increasingly apparent nowadays that wool cannot hold its place in competition with artificial fibres by relying upon its traditional virtues. Wool's citadel has been attacked with some success by the chemist, but there is plenty of scope and even adequate time for it to fight back, though every day is valuable.

So my answer to the question of " Can wool hold its place in the textile world ? " is : " Yes, it can, but to do so it must enlist the full resources of all branches of science ". Thus the veterinary workers are needed to prevent diseases that increase the cost of production, and the geneticist must be called in to improve the quality and quantity of wool produced and so lower costs. On the technical side, the physicist and the chemist must remove those disadvantages that are inherent to wool, and they might even improve it so greatly in other respects that it will be able to compete even more strongly as a textile fibre.

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# Rainfall, Production and Population in Victoria*

By

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Water, light, air and the earth and its constituents are the essentials of life. Each of these may, under varying conditions, become the limiting factor for growth and development. In discussions on future population and development, it is usual to speak in terms of the capacity of the earth and its constituents. In this paper, it is proposed to discuss the matter from the point of view of water as the limiting factor. None will deny that in Australia water is the limiting factor, but even where it is not, as in the United States of America, the importance of water in the economy of the country is being realised. This was expressed by President Roosevelt when he said:

> "The day will come when every drop of water that falls will be controlled for the benefit of mankind, for the growing of forests, for the irrigation of land, for the development of power, for the prevention of soil erosion, for the ending of floods, for the improvement of navigation."

In this paper, an endeavour has been made to show the relationship between the population and production of Victoria and its rainfall. The figures are not meant to be considered as final; that would be preposterous when one remembers the time and brain power that has been put into the question of determining the national income, and money is easier to measure than water. Actually this is an attempt to show a possible way of measuring the relationship between rainfall and production with a view, if it is thought justified, to making a more thorough investigation into the variables in the proposition.

Before discussing the variables, let us consider the facts. The rainfall map[1] of Victoria shows the division into the main zones of rainfall—ranging from the area with less than 12 inches in the north-west to the 80-inch rainfall of the eastern highland block. This latter area and the small areas in the Otways and south Gippsland are the only ones where there is excess water in an average year although, of course, storms and over-the-average rainfall may cause a run-off from any portion except the north-western Mallee. The eastern highland block is, however, obviously the only possible source of any quantity of water for irrigation, although run-off from other areas may be of use for domestic and stock purposes. This area, and its extension into New South Wales, has been rightly called the "Real Heart of Australia", as it is from it that the permanent rivers, as arteries, carry Australia's most precious

* Presidential address to Melbourne University Agricultural Society, 21st April, 1939.

possession, water, to the thirsty plains. The 12-inch isohyet, on the other hand, may be considered the boundary of marginal wheat areas.

A graph[2] is not necessary to show that the Victorian rainfall varies from year to year; that is common knowledge. But it is not generally realised that droughts are seldom of one year's duration, and that frequently three years of below-average rainfall follow each other. The longest period of this nature was from 1895-1902, when there were seven years in succession below the average. On the other hand, years above the average are also grouped so that the oft-quoted statement that the surplus water and growth can be stored for dry years is not easy of fulfilment, as it means storage not for one year but for several. In fact, it would appear from the graph that, like Joseph of old, in order to be prepared we should build storages and granaries for a seven years' drought. In considering also available water it must be remembered that, for economic reasons, it is difficult to carry over more than one year's surplus. Actually, therefore, a figure making allowance for this and which would be less than the average should have been used in these calculations.

Reference to the hydrologic cycle[3] reminds us that the water falling as rain may be directly re-evaporated, may run-off and either be used for irrigation and domestic and stock purposes or pass to the sea or soak into the soil and be transpired by plants, be evaporated from the surface, emerge as springs, again run off or accumulate as underground waters to be tapped or to soak to the sea. In definitely correlating rainfall and production, it would therefore be necessary to account or make allowance for the water used or dissipated in these various ways. In my calculations, I first endeavoured to arrive at a figure for the total water requirements of the present population and production of the State in a normal year. This falls into four divisions:

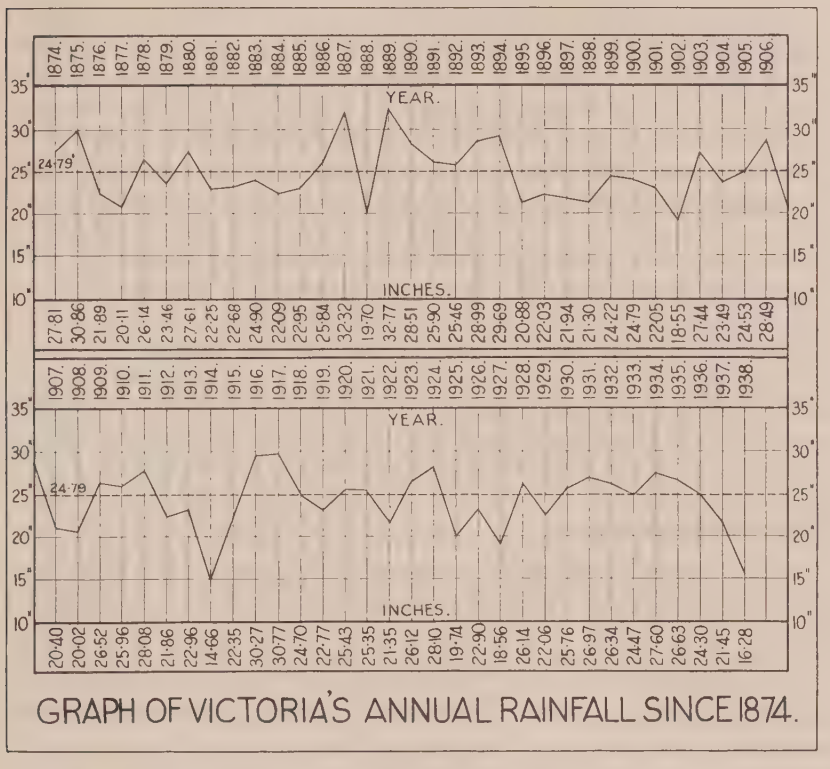
A. Water requirements for man and domestic animals.
B. Water requirements of the plants grown for food for man and domestic animals.
C. Water requirements of vegetable materials exported.
D. Water requirements of the timber areas of the State.

### Water for Man and Animals.

With regard to A, I used the figures for the year 1937 in which, as shown by the graph, the rainfall was 24·3 inches as compared with the average of 24·8.

The figure was computed on the following basis:

1,850,000 persons at 50 gallons per day.
357,000 horses at 5 gallons per day.
2,000,000 head of cattle at 5 gallons per day.
18,000,000 sheep at ½ gallon per day.
318,000 pigs at ½ gallon per day.
6,000,000 poultry at 1/24 gallon per day.




GRAPH OF VICTORIA'S ANNUAL RAINFALL SINCE 1874.

These total 41,600,000,000 gallons for the year, but I will describe later figures in terms of thousand million gallons, i.e. the above figure, as $41{\cdot}6 \times 10^9$ gallons.

With regard to the quantities above, 50 gallons per day was fixed per person on the basis of consumption per head in Melbourne and a number of other cities, and therefore includes manufacturers' requirements and luxury uses such as flower gardens.

### Water for Food Crops.

In calculating requirements in this connection, there are two variables—one is the quantity of dry vegetable matter consumed per day, and the other is the transpiration coefficient of this matter. Taking the first, I assumed the following daily rations of dry vegetable matter: 1½ lb. per person, 25 lb. per horse, 25 lb. per head of cattle, 2½ lb. per sheep, 5 lb. per pig, and 1/5th lb. per head of poultry. The amount per person includes an allowance for that used in the manufacture of liquid refreshment, i.e. malt and hops.

Turning to the transpiration coefficient, we are all familiar with the work done about twenty years ago in determining the water requirements of plants[4] by the Victorian Department of Agriculture. The results of these investigations set out the transpiration coefficients for various types of fodder and grain, and it was therefore necessary to make an assumption as to the nature of the dry matter eaten. Speaking generally, the departmental results ranged from approximately 400 for cereal hay to approximately 1,200 for grain; lucerne hay was intermediate at 800. No figure was worked out for green pastures or fodders, the former of which is important in a discussion of this nature. However, judging by the results of the irrigation of pasture experiments at Werribee Research Farm,[5] the coefficient for pastures would appear to be of the same order as that of lucerne hay. Taking this into account, I accordingly allowed for food eaten by sheep to be intermediate between hay and pasture at 500; for cattle and horses I assumed that some concentrates, lucerne, hay and pasture would give a coefficient of 800; whilst for man, pigs, and poultry I assumed practically all concentrates would have a coefficient in the vicinity of 1,100. In considering these figures it must be remembered, as stated by Dr. A. E. V. Richardson in his report:

> "The transpiration ratio is not a constant and definite quantity for any given crop, but it varies from season to season and from locality to locality due to natural climatic differences. It also varies with the period of the year during which the crop is grown."

There must, therefore, be a considerable margin for error in any figures chosen as transpiration ratios. However, subject to these reservations the quantity of water required to grow the rations of dry matter set out above is as follows:

| | | | | | |
|---|---|---|---|---|---|
| Persons: | 1,850,000 | at | 1½ lb. | per day with ratio of | 1,100 |
| Horses: | 357,000 | at | 25 lb. | ,, ,, ,, ,, | 800 |
| Cattle: | 2,000,000 | at | 25 lb. | ,, ,, ,, ,, | 800 |
| Sheep: | 18,000,000 | at | 2½ lb. | ,, ,, ,, ,, | 600 |
| Pigs: | 318,000 | at | 5 lb. | ,, ,, ,, ,, | 1,100 |
| Poultry: | 6,000,000 | at | 1/5th lb. | ,, ,, ,, ,, | 1,100. |

Some provision must also be made for the animals slaughtered during the year. For these I allowed three months on full rations, as follows:

| | | | | | |
|---|---|---|---|---|---|
| Sheep and lambs: | 8,000,000 | at | 1½ lb. | per day ratio | 600 |
| Cattle: | 500,000 | at | 25 lb. | ,, ,, | 800 |
| Pigs: | 500,000 | at | 5 lb. | ,, ,, | 1,100 |
| Poultry: | 1,000,000 | at | 1/5th lb. | ,, ,, | 1,100. |

The total of these is $3110 \times 10^9$ gallons.

### Water Requirements of Vegetable Exports.

After allowing for interstate trade in wheat, flour, dried and fresh fruit, the significant items in the vegetative exports are:

Wheat: 6,160,000 centals
Flour: 4,680,000 ,,
Dried fruit: 90,000,000 lb.
Fresh fruit: 55,000,000 lb.

Assuming for wheat and flour, transpiration coefficients of 1,100, and for dried fruits 1,000, and for fresh fruits 200, the total requirements for these is $129 \times 10^9$ gallons. The coefficient of 1,000 for dried fruits was considered to be approximately correct after a study of a number of duty of water measurements on sultanas and other vines.

### Quantity Required for Forest Growth.

Mr. A. O. Barrett,[6] by his researches at his home at Toorak, showed that Eucalyptus requires in the vicinity of 500 lb. of water per lb. of dry matter produced, but there is no measured crop to which this multiplier could be applied. An attempt was therefore made, by a comparison of the " run-off " figures of a number of forest catchments over a period of six years (1925-30 inclusive), to determine the quantity of water retained by the forest area per annum. The figures used were those of the River Gauging Branch[7] of the State Rivers and Water Supply Commission which determines for each catchment area the average rainfall and the percentage run-off from the river gaugings; thus for the Goulburn River above Eildon Reservoir, the average rainfall in 1930 was 39 inches and the run-off 40 per cent., leaving 60 per cent. (23·4 inches) in the catchment area.

These figures were determined for the Upper Murray at Jingellic, the Macallister at Glenmaggie, the Kiewa at Kiewa, the Goulburn at Eildon, the Mitta at Tallangatta, the Tambo at Ensay, the Ovens at Wangaratta and the Snowy at Jarrahmond. It is agreed that these catchments are not all forest and that some of them include cleared lands and others open country above the snow line, but it was considered that the average figure obtained, 25 inches, was a reasonable indication of the amount of the rainfall which would be retained in the soil of the non-agricultural mountainous areas of the State. The years chosen for the calculation (1925-30) were, however, mainly dry years, and probably over a period of average years this figure would be increased, but not to a great extent as this " water requirement of the catchment ", if it might be so termed, seems to have a range for each catchment depending probably on the nature of the vegetation, which is, of course, dependent on normal rainfall, elevation, slope and a number of other factors. It is felt, however, that the period taken was not the best and that a further investigation into this figure should be carried out. It is interesting to note, however, that on the Coliban catchment, part only of which is forest, the rainfall retained over an average of 50 years was 25 inches out of an average of 33 inches. This figure was obtained as part of a special investigation into the Coliban catchment and its vagaries. This figure of 25 inches includes, of course, evaporation from

the surface and underground percolation, but there seems no simple way of estimating these.

The areas on which timber is being grown fall into five categories[8]: (*a*) forest reserves, (*b*) unallotted crown lands in the highlands, (*c*) crown lands held under grazing licences in the highlands, (*d*) crown lands in process of alienation in timbered areas, (*e*) miscellaneous areas such as water frontages and reserves, roads, shelter belts, parks and gardens, beds of rivers and lakes.

On the first two areas the water requirement figure of 25 inches may be assumed:

(*a*) Forest reserves: 4,700,000 acres.

(*b*) Unallotted crown lands in highland areas: 2,614,000 acres.

The total accounted for in this way is $4146 \times 10^9$ gallons.

Crown lands held under grazing lease in the highland areas are included in the catchment areas of our main streams and therefore would have the average water requirement of 25 inches. On the other hand, however, they provide grazing for a number of cattle and sheep in the summer, and therefore some allowance has to be made to prevent duplication. On the basis of the grazing capacity checked by rental value, 1 inch should be sufficient allowance for this. Therefore 24 inches should be the water requirement of this 3,200,000 acres, making a total of $1740 \times 10^9$ gallons.

Crown lands in process of alienation in timbered areas are not very considerable; they are situated mainly in the eastern highland area and along other portions of the main mountain chain. The area is approximately 1,000,000 acres. It is difficult, however, to determine what figure would represent the water requirement of the timber in this area; on the basis of 25 inches for the purely forest areas, probably 20 inches would cover the requirement of the timber on these areas and evaporation therefrom. Using this figure, the amount used would be $454 \times 10^9$ gallons.

The miscellaneous areas, that is water reserves, beds of rivers and lakes, shelter belts, parks and gardens, etc., total 3,500,000 acres. A considerable proportion of this area, particularly of the river frontages and roads, is used for grazing and in addition the areas are spread throughout the State. Taking these points into consideration, it would seem that 15 inches would be a reasonable estimate for timber growth and evaporation. This would absorb $1191 \times 10^9$ gallons.

Summarising the figures for water accounted for in thousand million gallons, they are:

| | |
|---|---|
| A. Water requirements for animals .. .. .. .. .. | 42 |
| B. Water requirements for food growth .. .. .. .. | 3,110 |
| C. Water requirements for vegetative exports .. .. .. | 129 |

D. Water requirements for forest areas—

| | |
|---|---|
| (*a*) Forest reserves | 2,662 |
| (*b*) Unallotted highland crown lands | 1,482 |
| (*c*) Grazing leases—highlands | 1,740 |
| (*d*) Forest on lands in process of alienation | 454 |
| (*e*) Miscellaneous areas | 1,191 |

The total is $10{,}296 \times 10^9$ gallons, of which, however, $7529 \times 10^9$ are for forest areas, but this figure is inclusive of evaporation from these areas.

Assuming that the above water is used for the benefit of Victoria there is, on the other side, water lost to Victoria. This may be classified under the following headings:

1. Water passing into the ocean or out of the State.
2. Evaporation.
   (*a*) From unallotted crown lands not growing timber or leased for grazing.
   (*b*) From occupied areas not already included.
3. Water growing unused and surplus vegetable matter and weeds, including food for rabbits.
4. Underground losses.

Discussing these losses in turn:

1. The amount of water passing into the ocean or out of the State can be determined by considering the flow of the rivers. Of these, the main ones such as the Murray, the Snowy, the Yarra, the Mitchell and the Latrobe, are gauged regularly,[7] while measurements of some of the others have been made at intervals, so that an estimate of a total of six million acre-feet can be made—equal to $1632 \times 10^9$ gallons. This includes an allowance for water brought into the State by the Snowy River.

2. (*a*) Evaporation from unallotted crown lands not growing timber actually includes the water transpired from the grass and scrub on it, but as it is not used for domestic animals it is included here. The area under this category is approximately $3\frac{1}{2}$ million acres situated mainly in the north-west of the State and with an average rainfall of 11 inches, equal to $873 \times 10^9$ gallons on the area.

2. (*b*) Evaporation from the occupied areas not already considered is a difficult matter to estimate. It is dependent on the rainfall, the nature of the surface, the nature of the vegetation, the humidity and the temperature.

From a consideration of these factors and a number of results, I decided that 10 inches per annum was a reasonable estimate. On this basis, the evaporation on the area of the State not already included (37,932,000 acres) is $8607 \times 10^9$ gallons.

The other two items—water growing unused vegetable matter, weeds and feed for rabbits, native animals and birds, and water lost underground—do not seem capable of estimation. Something might be done regarding food eaten

by rabbits from a calculation of skins and rabbits sold, but it would be subject to even a larger error than some of the estimates already made. There is also no way of estimating water lost underground, that is, either water percolating through into the ocean or to another State or water remaining in the soil to increase the ground water level. There is no doubt, however, that water in considerable volumes does find its way to the sea in this way.

### Summary Regarding Use of Water.

A summary of all items in the use of water may now be prepared as follows :

*Year* 1937. All figures in thousand million gallons (column A) and thousands of acre feet (column B).

| | A | B |
|---|---|---|
| *Rainfall.* 24·3 inches on area 56,245,000 acres .. | 31,008 | 113,767 |
| *Water used in Economic Activities of the State* | | |
| A. Water requirements of population and animals .. | 42 | 154 |
| B. Water requirements for food growth .. .. | 3,110 | 11,411 |
| C. Water requirements for vegetable exports.. .. | 129 | 473 |
| D. Water requirements for forestry areas (including evaporation) .. .. .. .. .. | 7,529 | 27,624 |
| | 10,810 | 39,662 |
| *Water Lost to the State* | | |
| 1. Flowing into the ocean or out of the State .. | 1,632 | 5,988 |
| 2. (*a*) Evaporation from desert areas .. .. .. | 873 | 3,203 |
| (*b*) Evaporation from occupied areas .. .. | 8,607 | 31,577 |
| | 11,112 | 40,768 |
| *Balance* | | |
| Losses underground and water growing surplus vegetable matter, weeds and food of rabbits and native animals | 9,086 | 33,337 |

Although these figures are approximate, they show that in an average year there is a limit to the expansion of the agricultural and pastoral activities of the State. Certainly if the whole of the balance of $9086 \times 10^9$ gallons could be converted to economic uses, the population and live stock could be trebled, but there must always be, even under the most carefully controlled system of agriculture, losses of vegetation and also the loss of water underground.

It also has to be remembered when thinking on the basis of population only that the live stock, for the food of which provision was made, also provide

wool, mutton, lamb and dairy produce for export and that these, together with the cereals exported, would provide food for a very considerable increase in the population without any increase in the efficiency of production.

### Position in a Drought Year.

When, however, we turn to a drought year the position becomes very different. Take, for instance, the year 1914 which, as will be seen from the graph, was the third of three dry years—in this it is comparable with 1902 and 1938. In 1914, the total rainfall was 14·66 in., which equals $18{,}707 \times 10^9$ gallons. Assuming the same population and live stock as at present, the requirement would be of the following order :

A. *Water Requirements of Population and Animals.* This would be higher for the animals on account of drier feed and lower humidity, whilst that used by the people might be reduced by restrictions. It is felt that these variations could be allowed for by increasing the figure from 42 to $45 \times 10^9$ gallons.

B. *Water Requirements for Food Growth.* The researches at Rutherglen and Werribee showed that in drought years the water requirements of plants increased ; in fact, " average transpiration for cereals in a typically drought year at Rutherglen was 546 as compared with 273 for a favourable season "[4] which represented a difference of 100 per cent. in the ratio for two seasons.

Although this applied in the more arid parts of the State, it would not apply to the more humid parts, such as Gippsland, so that a reasonable increase over the whole would be 50 per cent., making this item $4665 \times 10^9$ gallons.

C. *Water Requirement for Vegetative Exports.* This item would be nil as regards wheat and flour but dried fruits would probably be exported on a basis similar to an ordinary year, and their requirement would probably be increased due to lower humidity but not to the same extent as cereals, as they are normally grown under irrigation in a dry climate. An increase in their requirement from 9 to 10 thousand million gallons, therefore, is all that seems justified.

D. *Water Requirement for Forestry Areas including Evaporation.* Although trees, like the cereals and other plants tested at Werribee and Rutherglen, would probably require more water to give the same growth in a drought as a normal year, they get in a drought year less water and consequently make less growth. Owing to the steepness of the slopes and heaviness of some falls of rain, everything that falls on a watershed cannot be retained even if the soil is below field capacity and there is some run-off. The reduction is, of course, very much greater in the run-off than in the water retained ; thus on the Goulburn catchment when the rainfall was 48 inches, 27 inches were retained, and when it was 32 inches, 19 inches were retained. On the Coliban when rainfall was 50 inches, 30 inches were retained, and when it was 22 inches, 21 inches were retained. Taking the average of the various catchment areas, the minimum amounts retained in dry years averaged 20 inches compared with the average

of 25 inches, and a *pro rata* reduction brings the item under this head to $6023 \times 10^9$ gallons.

Turning to the water lost to the State, Item 1, water flowing into the ocean or out of the State has been determined by estimating from known river gaugings, and found to be $707 \times 10^9$ gallons.

Item 2 (*a*) Evaporation from desert areas is reduced to the rainfall on these areas, viz. $5\frac{1}{2}$ in., which equals $436 \times 10^9$ gallons.

Item 2 (*b*) Evaporation from occupied areas is very difficult to estimate. In the drier parts of the State it will probably be lower than in a normal year on account of lower rainfall, whilst in the more humid portions it will be higher on account of lower atmospheric humidity. It will therefore be in order to adhere to the figure for the normal year, viz. $8607 \times 10^9$ gallons.

### Summary of Water Use in Drought Year.

The position in a drought year may, therefore, be summarised in thousand million gallons (column A) or thousands of acre-feet (column B), as follows:

| | A | B |
|---|---|---|
| *Rainfall.* 14·66 ins. .. .. .. .. .. | 18,707 | 68,636 |
| *Water used in Economic Activities of the State* | | |
| A. Water requirements of population, animals and manufacturers .. .. .. .. .. | 45 | 165 |
| B. Water requirements for food growth .. .. | 4,665 | 17,116 |
| C. Water requirements for vegetative exports .. | 10 | 37 |
| D. Water requirements for forestry areas (including evaporation) .. .. .. .. .. | 6,023 | 22,098 |
| | 10,743 | 39,416 |
| *Water Lost to the State* | | |
| 1. Flowing into the ocean or out of the State .. | 707 | 2,594 |
| 2. (*a*) Evaporation from and growth on desert areas | 436 | 1,600 |
| (*b*) Evaporation from occupied areas .. .. | 8,607 | 31,579 |
| | 9,750 | 35,773 |
| *Deficit* | | |
| Amount by which rainfall is short of the needs of the State, and which will be increased by underground losses, and water growing surplus vegetable growth, weeds and food of rabbits and native animals.. .. | 1,786 | 6,553 |

It is therefore obvious that in a drought year there is a considerable deficiency and this is, of course, shown by the fact that in such a year reserves of fodder are consumed, stock die from starvation, and water conserved in

reservoirs both for domestic use and irrigation is greatly reduced in volume or used up entirely. In such a year, underground reserves of water are also used to a greater extent than in a normal year and actually more may be taken from, than is added to, them.

## Conclusions.

It is apparent that to increase our population and live stock in their present ratios greater efficiency in the use of our rainfall must be obtained and that, in addition, storage of surplus production and rainfall of above average years must be considered on a national basis.

Population itself could, as stated above, be increased by a reduction in stock carried, reducing the export of meat and butter, an increase in the proportion of vegetable matter eaten or by an increase in fish consumption. Efficiency in the use of water is, of course, sound agriculture and is also the basis for research into varieties of wheat suitable for dry conditions, and this paper indicates the necessity for further research along these lines. To a greater extent, it indicates the necessity for a sound system of fodder preservation and storage—storage of water alone is not sufficient. One acre-foot, the storage space for which under present conditions costs £5 to £10, will, after allowing for losses in transmission, grow about one ton only of dry fodder. The amount of water that can be stored and storage sites are also limited.

In conclusion, it is pointed out that in these figures only a scratch on the surface of the attack on the problem from this angle has been made, and it is felt that if each item on the balance sheet were considered by those whose speciality it happens to be, a more accurate result could be obtained.

The question has been asked why Great Britain, with a similar area to Victoria and approximately a third more average rainfall, can support the population and stock it does. It has to be remembered that Great Britain is not self-sufficient in the wants of its stock, let alone its population, and every form of foodstuff imported has an equivalent in water. Thus every ton of wheat and flour equals an acre-foot of water, and every ton of butter two and a quarter million gallons or nine acre-feet. What the equivalent is to each pound of lamb and mutton is difficult to say, but it would be found that the total water equivalent of the imports into Great Britain is quite considerable whilst the water equivalent of the meat and butter exported from Victoria has also to be allowed for.

## References.

[1] Map in Rainfall Observations in Victoria, 1911-1936. Bureau of Meteorology, 1937.
[2] Prepared from Figures in above Report.
[3] Original drawn by Mr. W. J. Lakeland, Forest Engineer, Forest Commission, Victoria.
[4] Richardson, A. E. V. Victorian Journal of Agriculture, 1923.
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# Insects and Their Influence on Agricultural Development*

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Any settlement project, be it large or small, presupposes a survey of both soil and climate to determine what crops can, and what crops cannot, be grown. In a tropical area, one must think primarily in terms of tropical crops ; in temperate areas, in terms of temperate crops. Having then narrowed down the number of potentially suitable crops to manageable dimensions, their marketing possibilities must be explored. As a general rule progress is made " cannily " by trial and error methods, a variety of crops being grown so that losses, equally with gains, will be low until such time as both crop possibilities and marketing possibilities can be determined in practice with reasonable accuracy. More rapid progress is then permissible, for experience coupled with any scientific aid which may be available should obviate any major calamity.

The agricultural history of Australia, in common with that of other countries, presents a chequered picture with ups and downs which are not altogether related to price fluctuations of the marketable products. Climatic and soil conditions are very variable, and accurate agricultural knowledge capable of rapid adaptation to Australian conditions was not available in the early days of settlement. It is thus improbable that the agricultural features of the younger and less densely settled parts of Australia are established with any permanency. Crop interests may vary and the incidence of insect pests may therefore have an important influence on agricultural development in the future.

Insects may influence development in any one or more of three ways. They may undermine the health of the farmer (mosquitoes and sandflies are culpable in some countries) ; they may lower the vitality of his stock (insects may merely irritate animals or transmit disease organisms) ; and they may attack crops.

In Queensland, biting and sucking insects may both attack man and cause not a little irritation to stock, but they can scarcely be considered a limiting factor in rural development. Pests of crops, if past experience is any criterion, are much more important and require consideration in some detail. The subject is a very wide one and must be restricted here to a few points of interest in settlement projects.

* Based on a lecture to the Queensland Branch of the Australian Institute of Agricultural Science.

**Emergence of Indigenous Insects as Pests.**

During recent years white grubs, long known as pests of sugar cane, have made serious inroads into the productivity of pastures in some dairying districts. Recent work on the subject in North Queensland indicated quite clearly that the importance of white grubs is to some extent linked with soil fertility and methods of farm management. With the opening up of rain forest country and the establishment of permanent pastures, a marked increase in the numbers of an indigenous Scarabæid, *Lepidiota caudata*, has occurred on the Atherton Tableland. So long as the fertility level of the soil was high the importance of the pest was not appreciated, for the land remained productive. With the inevitable decline in fertility over a period of 20 to 50 years, the pest gained the upper hand ; pastures produced little feed and the depredations of the pest then became more obvious. Financial returns in some parts of the district ceased to be remunerative and prospects looked very black indeed. The struggle between farmer and pest is now more evenly balanced for there is clear evidence that while permanent pastures cannot be relied upon to provide the food requirements of the herd, a mixed farming programme based on short term pastures and cultivated fodder crops can supply the requirements of dairy herds in the white grub infested belt. Elsewhere, related species constitute identical problems which will doubtless require similar solution, though details may vary from district to district. Incidentally, it should be noted that the pest has forced farmers not only to realise the practicability of solving a pest problem by agricultural methods, but also of overcoming cultural difficulties hitherto regarded as insuperable.

The second example is fresh in the memory and doubtless has a wider appeal. The habits of grasshoppers vary but the species of most interest in Queensland and New South Wales, the Australian plague locust, *Chortoicetes terminifera*, has specialised egg-laying habits. It prefers light-soiled, timberless tracts in which to lay eggs. When numerous it may, of course, lay almost anywhere, but there can be little doubt that the location and extent of suitable egg-bed country are important factors in determining the dimensions of an outbreak such as that of 1937. As a general rule, virgin country of this kind is timbered and as long as it is timbered, grasshoppers cannot use it for egg-laying and the possible scope for a rapid increase in numbers is proportionately limited. Agricultural and pastoral development has necessitated the ring-barking and clearing of much of this country and it is, therefore, reasonable to infer that these activities have, to some extent, been responsible for grasshopper outbreaks in localities previously unaffected. It may conceivably be necessary in the future to treat some of this country to exclude the pest, e.g. by replanting timber or edible shrubs, if losses over a period of years exceed the cost of control measures plus the agricultural value of the land concerned.

Both the above examples illustrate the emergence of indigenous insects as important pests following ecological changes in an area brought about by

necessary developmental work. Clearing, though essential if land is to be cultivated or profitably used for pasture purposes, has automatically removed important limiting factors to the increase in numbers of both insects. In the case of white grubs, the available food supplies have been increased ; in the case of grasshoppers, additional egg-bed sites have been provided.

### Influence of Pests on the Geographical Location of Primary Industries.

The location of tropical fruit-growing areas in Queensland has, in the past, been determined primarily by marketing considerations. The large consuming centres are obviously the capital cities in the south, and fruits such as the banana and pineapple have been grown in Queensland principally in the southern part of the State to permit the marketing of fresh fruit in good condition. With modern transport, cool storage and ripening facilities, proximity to market is a less pressing need than formerly, and any extension in the area planted to tropical fruits may involve hitherto unexploited or partially exploited areas where climatic and soil conditions appear favourable. Superficially it may appear that the far north, with its heavy rainfall and warm temperatures, would prove more suitable for banana production than southern Queensland. Actually, however, even though soil and climate may be favourable it is very probable that banana production in the far north will be hampered by entomological problems.

The banana fruit fly, *Chætodacus musæ*, related to the Queensland fruit fly, *C. tryoni*, but confined to bananas and to north Queensland, is known to injure fruit long before it matures on the bunch and has been to some extent responsible for earlier failures to commercialise production. Another pest, the banana rust thrips, *Scirtothrips signipennis*, though distributed along the whole coastline, is much more destructive in the far north than in banana growing areas in the southern parts of the State. Both pests will inevitably play havoc with any large scale commercial venture in the far north unless adequate control measures are available. Fortunately, control measures recently devised for the banana rust thrips in southern Queensland may also prove effective in the north for both this pest and the banana fruit fly. Any northward trend in banana production may therefore be viewed with more equanimity later on.

Another example of the influence of pests on the location of a primary industry can be drawn from Stanthorpe, the centre of deciduous fruit-growing in Queensland. From the point of view of soil and climatic suitability, some parts of the Darling Downs should be at least equal, if not superior, to the Stanthorpe district for the production of stone fruits. At present, these fruits are grown on a semi-commercial basis in the vicinity of Toowoomba and Warwick but the annual losses due to the Queensland fruit fly make any major

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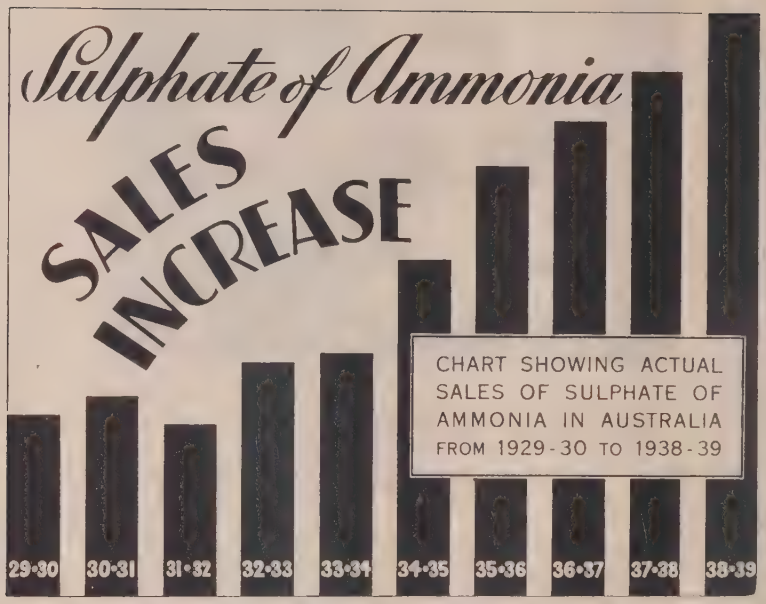



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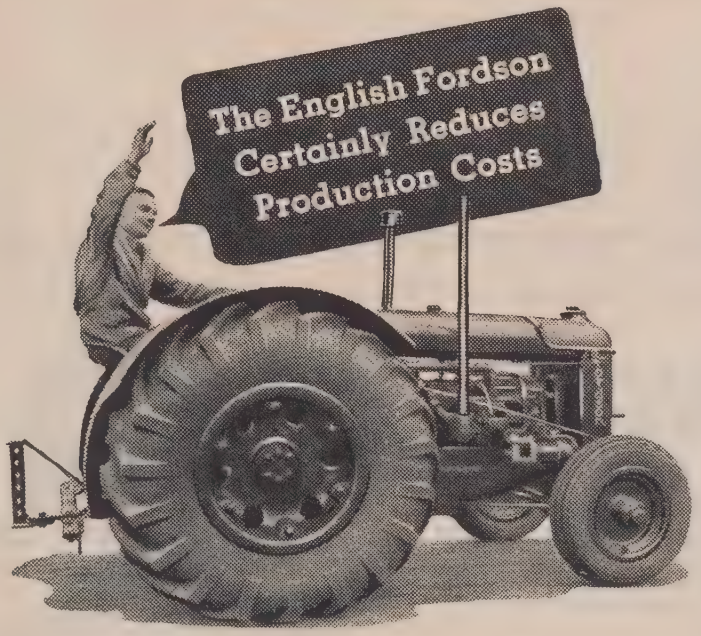


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development well nigh impossible. The pest, of course, causes losses at Stanthorpe—sometimes quite severe losses—but these are normally less important than those in fruits grown at lower altitudes. Were fruit fly no more important on the Darling Downs than it is at Stanthorpe, the acreage under stone fruits would unquestionably extend if marketing outlets were available.

Both the foregoing examples suggest that insect pests are sometimes important factors in determining the location of primary industries. If soil, climate and marketing possibilities alone were involved significant changes—sometimes great, sometimes small, but frequently significant—would probably take place.

**Forecasting Entomological Trends.**

Though insects can and do play a large part in agricultural development, existing entomological knowledge is frequently insufficient to determine with any exactitude the possible pest trends in any developmental project. Care is obviously necessary to exclude insects which are known as serious pests in other countries, and any laxity in quarantine precautions is entomologically inexcusable. The same principle has a more local application within the boundaries of a single State, e.g. in various restrictions such as those controlling the movement of banana suckers in Queensland—a necessary precaution in any attempt to exclude banana rust thrips and banana weevil borer from new areas.

The pioneer in agriculture must to some extent explore entomologically uncharted country, for even though exotic pests may be excluded, it is still probable that insects already maintaining a precarious existence on the native flora may become partial to some cultivated crop. This depends largely on the adaptability of the species, and the point must be stressed that many native insects are capable of acquiring a partiality for introduced agricultural and horticultural crops. Thus though the Queensland fruit fly is indigenous to the State, it now attacks a wide variety of introduced cultivated fruits. In fact, the extent to which the latter are grown largely determines the population density of the species.

It might be inferred that a detailed knowledge of both native and introduced pests should enable an entomologist to indicate the probable pest position in any proposed settlement. Research will certainly help but it still remains true that a forecast based on even a very detailed knowledge of an insect may go astray. An example can be given here.

The Mediterranean fruit fly, *Ceratitis capitata*, a very widely distributed pest, is of first rate economic importance in several fruit-growing countries in sub-tropical and tropical climatic zones. It has, therefore, been studied in considerable detail and the information on its habits, distribution, etc., is very extensive—sufficiently so to permit the assumption that the insect would become a serious pest throughout fruit-growing areas in Australia once it became established. The pest did get a footing in this country, and some

years ago was common in both Western Australia and New South Wales. In the former State, the Mediterranean fruit fly has steadily increased in importance, attacking not only the known host fruits but others, such as grapes and tomatoes, which were previously considered immune. In New South Wales, the insect has lost ground, and in Queensland it has never been bred from locally grown fruit. In both these States, developments comparable with those in Western Australia were expected but fortunately expectations, though justified by extensive research overseas, have been falsified by events. All explanations are conjectural and do not warrant consideration here.

The accuracy of any such forecasts presupposes a complete knowledge of an insect's behaviour. Such knowledge is always incomplete for an insect in a new environment is faced with problems which differ in some respects from those in which the insect has previously been studied. It may thus prove either more destructive or less destructive than anticipated, and the inevitable uncertainty is the main justification for quarantine precautions, whether of general or local application.

### Cultural Practices and Pest Problems.

Of the numerous pests recorded in Queensland, some attack the host plant irrespective of its vigour but others only seriously injure the host if it is, for any reason, weak. Very few crops pass from germination to maturity without some setback, and efficient farming presupposes adequate attention to cultural practices which tend to even out the growth rate and obviate any checks. Standards of efficiency vary, however, and some pests are linked consistently with crops which are either ill-managed or grown under adverse soil or climatic conditions which cannot be offset by efficient management. Until recent years, it has been commonly assumed that if an insect is numerically abundant on a crop which has failed, then the insect is the essential cause of such failure. This assumption, though the obvious one, may not necessarily be true for numerous instances are known in which cultural defects aggravate the pest position and tend to mislead the observer. The banana weevil borer, *Cosmopolites sordidus*, may be cited as an example.

For many years this insect has been regarded as a major pest in various banana-growing countries, including Australia, and there can be no question that it has been and is both numerically abundant and frequently destructive. In spite of detailed work on its life history and control, there has for long been a feeling in entomological circles that recommended control measures, though certainly giving relief and therefore justified on that account, were incomplete without some reference to cultural matters. The feeling was doubtless fostered by a common observation that when a pest occurs in both living and dying plant tissues (as is the case with the banana weevil borer), it may be primarily saprophagous in habit and secondarily a pest. Wallace, in New South Wales, has investigated this point, and his work demonstrates that

susceptibility to banana weevil borer attack is largely determined by plant vigour in the host. Banana plants adversely affected by climatic or cultural conditions may suffer, but the healthy plant is less susceptible. It is obvious, therefore, that a due appreciation of the cultural requirements of the banana plant and their fulfilment in practice would go far to solve this problem, though recognised control measures may, and probably will, still be necessary.

It is perhaps significant that in some countries, such as Malaya and Java, the banana weevil borer, though numerous, is not a pest. This phenomenon has been ascribed to the influence of indigenous parasites and predators which undoubtedly are present and, no doubt, do some good but, in view of Wallace's work, other factors may explain the known status of the pest in these countries. Both Malaya and Java possess a heavy rainfall which is more or less evenly distributed through the year. They also possess equable temperatures. Seasonal extremes, wet and dry, hot and cold, are less important in those countries than in Australia. It is improbable, therefore, that the banana plants receive the cultural setbacks so noticeable in both Queensland and New South Wales, and they should therefore be less subject to banana weevil borer attacks. As a corollary, it follows that while cultural improvements in Queensland may offset the pest to a considerable extent, supplementary control measures may still be necessary, for at times there are periods in the life of even well-managed plantations when vigour falls below par and the plant becomes susceptible.

In any pest-plant association, it is therefore unwise to assume that the pest is the first cause of crop failure. If cultural conditions are ideal and damage still occurs, there is definitely a pest problem. If cultural conditions cannot be improved further owing to unfavourable soil and climate, insecticidal control may make the difference between profit and loss on a property.

When land is first settled, farming methods are apt to be primitive until the land has been stumped and finance is available to purchase equipment. Even then, efficiency presupposes that operations are conditioned by research investigations into the cultural requirements of the crop. In the absence of these investigations, yields may be relatively low and the crop weak, with a definite susceptibility to attacks by pests. It is therefore necessary to analyse carefully losses commonly attributed to pests, particularly in the case of agricultural crops where only indirect, and thus inexpensive, control measures for pests are usually practicable.

It should be clear from the foregoing discussion that the success of settlement schemes frequently depends on a proper appreciation of the probable pest position to be encountered. Some of the risks can be obviated by quarantine precautions, while others can be surmounted by cultural attention to the crop. Economic entomology is concerned not only with the evaluation of these risks but also in solving current problems which interfere with profitable land utilisation.

# The Nitrogen Economy of Wheat Soils*

## WITH SPECIAL REFERENCE TO NON-SYMBIOTIC NITROGEN FIXATION

By

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In Australian agriculture, it is a well-known fact that the use of nitrogenous fertilisers is regularly of little or no effect in improving the yields of wheat, at least after fallow, which in rational farming mostly precedes the wheat crop. Nitrogenous fertilisers are therefore hardly ever used in wheat farming. On the other side, it may be calculated that the average annual wheat crop of New South Wales, viz. some 50 million bushels, takes away about 25,000 tons of nitrogen each year from the wheat lands. This is in the grain alone ; when we add to this the considerable amounts of nitrogen lost by stubble burning and removed in other crops (wheat for hay or grazing, oats for grain, hay or grazing, and natural vegetation appearing on stubble fields and fallows and eaten by stock) we probably come nearer to an estimate of some 35,000 tons of nitrogen being annually carried away from the wheat lands. Unless there are natural factors that compensate for this loss, the wheat cultivation must obviously represent a gradual consumption of the nitrogen reserves of the soil, eventually resulting in permanent loss of fertility.

The most important factors that might be considered as having such a compensating effect are the following :

(1) Nitrogen fixation by free-living soil micro-organisms.
(2) Nitrogen fixation by leguminous plants, wild or cultivated.
(3) Nitrogen brought down in the rain water.

Among these factors, the first has frequently been credited with a high importance in soils from hot, arid or semi-arid climates similar to that of the main parts of the Australian wheat belt. The experience that in many parts of India, wheat or rice have been grown for centuries without any fertilisers and without apparent loss of fertility has often been quoted in support of this theory. It has also been observed repeatedly that soils continuously cropped to cereals without nitrogenous fertilisers tend to reach a certain state of equilibrium where they give a low, but fairly constant, crop yield and show a nitrogen content that appears constant or decreasing only at an imperceptible rate. The ancient wheat fields on Broadbalk, Rothamsted Experimental Station, England, furnish the classical example of this phenomenon.

* Based on an address to the N.S.W. Branch of the Institute, July 14, 1939.

Other field experiments again indicate the possibility that soils left uncultivated for a number of years may gain nitrogen at the rate of some 20 to 40 lb. per acre per annum. Of all these observations, however, it must be said that numerous sources of error (variability in the composition of the soil, technical pitfalls in the determination of nitrogen, gains or losses of nitrogen by various uncontrolled factors) tend to obscure the results and to make it difficult to estimate, firstly, the actual magnitudes of the gains of nitrogen, and secondly, the relative importance of fixation by free-living organisms on the one hand, and other factors on the other. Vast amounts of laboratory investigations have been devoted to this problem, so far without giving a final answer.

According to the present state of our knowledge, only three groups of micro-organisms are definitely capable of fixing elementary nitrogen without symbiosis with a host plant:

(1) Aerobic bacteria of the genus Azotobacter.

(2) Anaerobic bacteria (butyric acid bacilli) of the genus Clostridium.

(3) Certain blue-green algæ.

Besides these, large numbers of bacteria, fungi, etc., have been credited with the power of nitrogen fixation, but in the light of more recent research these contentions must be regarded as questionable or actually erroneous.

Azotobacter has commonly been regarded as the most important among the free-living nitrogen fixers, on account of its high efficiency in pure cultures, where normally 10 to 12—in certain cases even as much as 20 to 25—parts of nitrogen are fixed per 1,000 parts of favourable carbon compound (glucose or mannite) consumed. (Incidentally, no conclusive evidence has ever been brought forth to show that this degree of efficiency can be surpassed when the organism is growing in its natural habitat, i.e. in the soil and associated with the rest of the soil micro-population). As to the various environmental factors that influence the activity of Azotobacter in the soil, the following are worth mentioning.

### Factors Influencing Activity of Azotobacter.

The growth of Azotobacter is limited to a range of temperature from about 10° C. to about 45° C. Its susceptibility to acid reaction is very marked; no nitrogen is fixed at pH values below 6·0, and an optimum exists at pH 7·0-8·0. The organism is therefore rarely found in soil of pH below 6, and is most common in neutral to moderately alkaline soils. Free access of oxygen and a liberal supply of available phosphoric acid in the medium are essential, and the process of nitrogen fixation is strongly activated by traces of metals like vanadium and particularly molybdenum. Presence of nitrate or ammonium salts, on the other hand, tends to check the process of fixation, but not the growth itself (except in so far as the growth of Azotobacter may be hampered when the presence of combined nitrogen enables other micro-organisms to compete for the available sources of carbon), since the nitrogen fixation is not

an obligatory but a facultative biochemical function which Azotobacter chiefly resorts to in the absence of a source of combined nitrogen.

As to the kind of carbonaceous food material used by Azotobacter in the soil, it should be remembered that " optimal " nutrients like sugars or higher alcohols are unlikely to be available, except perhaps in rather abnormal cases such as where fields are dressed with molasses, as is sometimes done in sugar-producing districts. Normally, its staple food is more likely to be simpler organic compounds of lesser energetic value, namely, lower alcohols and organic acids produced in the fermentation of complex plant residues in the soil.

The current statement in text books that " free-living N-fixing bacteria may be estimated to add from 20 to 40 lb. N per acre per annum to the soil " seems often based on the tacit (but unwarranted) assumption that the bulk of the organic matter transformed in the soil is actually consumed by Azotobacter or other nitrogen-fixing organisms supposed to possess a similar degree of efficiency. Since there is a definite upper limit to the ratio between quantity of nitrogen fixed and of carbon food consumed, the crucial point of the problem really becomes the quantity of nitrogen-free organic matter *actually consumed by Azotobacter cells that build up their protoplasmic substance with the use of free nitrogen.*

A series of investigations based upon these considerations has been carried out by the writer. The main results are summarised briefly in the following pages. The full account will appear subsequently in the *Proceedings of the Linnean Society of New South Wales.*

## Conclusions from Investigations.

A number of soil samples, mainly from the wheat belt in New South Wales, have been examined for the occurrence and numerical representation of Azotobacter. This survey included 123 soil samples, representing many different soil types, and of a range of reaction from pH 4·5 to 8·3, the majority being within the pH interval 5·5-6·5.* Out of 66 soils of pH 6·0 and less, only 6 (or 9 per cent.) harboured Azotobacter, while this organism was found in 24 (or 42 per cent.) of the 57 samples of pH 6·1 and more. This agrees completely with what has been found in other parts of the world. Quantitative estimations of the density of the Azotobacter population showed that their occurrence was in most cases only quite sporadic—from three to ten colonies per gramme of soil, or very often so few that a quantitative estimate was impossible. Only four samples, all fairly rich in humus and of pH 6·6 to 8·0, exhibited what we may consider a fair density of Azotobacter—from about 600 to 2,400 colonies per gramme ; of these soils, only *one* came from the

* Moderately acid reaction thus seems prevalent in the soils from the wheat belt of New South Wales. Systematic investigations into this question would be highly desirable.

wheat belt (a heavy brown basaltic loam from Curlewis, N.S.W.). These figures agree quite well with others found in South Australia by Beck, who used a somewhat different method. Summarily, it may thus be said that Azotobacter is only quite sparsely represented in the soils of the wheat belt.

In pure culture, numerous strains of Azotobacter showed a normal, or if anything rather high, nitrogen-fixing efficiency, whereas a number of other micro-organisms cultivated under the same conditions failed to show even the slightest evidence of nitrogen fixation.

Quantitative nitrogen determinations in soils with addition of glucose as food material for nitrogen-fixing bacteria, showed that considerable amounts of nitrogen may here be gained, but only if the soil conditions are such as to permit an abundant growth of Azotobacter. Other groups of organisms, or special acid-resistant types of Azotobacter,* do not appear to be active. A series of qualitative experiments showed that nearly all wheat soils are too poor in available phosphoric acid to allow Azotobacter to flourish abundantly, even if all other environmental factors, including the reaction, are made optimal.

Other nitrogen fixation experiments were carried out with straw and root material added to the soil, as representing a more natural type of organic food material. Gains of nitrogen were recorded only when the decomposition was allowed to proceed for periods of months in soil of *high* moisture content and of a reaction adequate for the development of Azotobacter. In all cases where nitrogen fixation could be detected, the numbers of Azotobacter rose to an order of magnitude (millions per gramme of soil !) altogether incomparable with those seen under natural conditions ; indeed, the numbers were so high that the amounts of nitrogen fixed could, with good approximation, be accounted for as cell substance of Azotobacter. On the other hand, there was often seen a considerable multiplication of Azotobacter which was *not* accompanied by a discernible gain of nitrogen. Generally speaking, a gain of two to three parts of nitrogen per 1,000 parts of straw or root material added to the soil appears to be a favourable yield.

In other series of experiments in soils incubated without any extra addition of organic material, no increase in nitrogen content could ever be detected. This is in contrast with what has frequently been stated in the literature. The soil " humus " itself thus does not come into consideration as food material for nitrogen fixation, and in view of the many possibilities of error that are involved, we may well be justified in regarding the many claims to the contrary with scepticism.

* Organisms of such a type have very recently been described by Indian and American investigators ; the present writer has not yet found any evidence that they occur in Australian soils.

Unlike Azotobacter, anaerobic nitrogen-fixers of the *Clostridium butyricum* group were, indeed, found in nearly all soils examined for their presence, but they appeared to become active and to fix nitrogen only in water-saturated soil supplied with sugar or starch. Since, also, their yield of fixed nitrogen per unit of consumed nutrient material is lower than in Azotobacter, their activity can hardly be credited with any practical significance under the conditions obtaining in the wheat soils. The same may be said of the nitrogen-fixing blue-green algæ, some representatives of which were also found in the present series of investigations. In soils especially favourable for algal growth, such as for instance rice soils during the period of flooding, these organisms may perhaps be of some significance.

We thus see that in the wheat soils of New South Wales the conditions for nitrogen fixation by Azotobacter are generally far from favourable, largely due to acid soil reaction and/or phosphate deficiency, and that other micro-organisms hardly come into consideration as non-symbiotic nitrogen-fixers of any significance. Furthermore, smaller or larger quantities of nitrate or ammonia are usually present in the wheat soils (especially during and after bare-fallowing), and this, according to the best of our present knowledge, is incompatible with at least a vigorous fixation of nitrogen. Finally, under the commonly adopted systems of continuous wheat cultivation (alternating wheat and fallow, or wheat-oats-fallow rotation) only moderate quantities of organic plant residues are returned to the soil. The amount of straw may roughly be estimated at 100 lb. per bushel of wheat, but the larger part of this is, of course, generally lost by stubble burning. It is probably a liberal estimate to assume that root and stubble remains of wheat, plus residues of spontaneous vegetation on the stubble fields and fallows, on an average supply 100 lb. dry organic matter to the soil per bushel of grain harvested ; this organic matter would be largely cellulosic material, requiring decomposition under a high degree of moisture in order to serve for nitrogen fixation. Therefore, only a remarkably favourable combination of circumstances (neutral to alkaline soil reaction, adequate phosphate supply, high degree of soil moisture for fairly long periods of a suitable temperature, etc.) could lead to a gain of 0·3-0·4 lb. N per 100 lb. organic matter, compared with approximately 1·2 lb. N in each bushel of wheat grain. In other words, non-symbiotic nitrogen fixation on the basis of residues from crops, spontaneous vegetation, etc., may *at the best* cover from about one-fourth to one-third of the nitrogen requirements of the wheat crop. Even if all straw could be returned to the soil instead of being burned, the yield of fixed nitrogen would be inadequate.

As to the amounts of organic matter elaborated by soil algæ or given off by the plant roots as organic secretions, these may safely be regarded as too small to be taken into consideration, apart from the fact that not all these compounds may be suitable nutrients for Azotobacter ; this appears certainly

to be true of the organic root secretions of the wheat, in whose rhizosphere therefore no active nitrogen fixation can be expected to take place.*

## Final Conclusion.

We thus arrive at the final conclusion that non-symbiotic nitrogen fixation is, at the best, a minor and mostly a quite insignificant factor in maintaining the nitrogen content of soils under wheat cultivation ; and that bare-fallowing is a two-edged sword, inasmuch as it certainly provides accessible nitrogen in the form of nitrate for the subsequent crop, but does so at the expense of the original nitrogen reserves of the soil humus—a fact to be kept in mind in connection with the problem of soil erosion.

When, nevertheless, we find soils that have produced wheat crops for 50 or 60 years, or even longer, without any apparent loss of fertility, then it must be remembered that exhaustion of the nitrogen reserves of a soil is in any case a lengthy process (witness the classical wheat fields on Broadbalk, Rothamsted). Further, the effects of rain and of wild leguminous plants enter as by no means negligible factors, especially where the crop yields are low.

The amount of nitrogen brought down with the rain water may be estimated at 3 to 4 lb. per acre per annum, i.e. in five to six years sufficient nitrogen for an average wheat crop, but investigations on the nitrogen content of rain water in New South Wales would be desirable.

The effects of wild leguminous plants are difficult to gauge, but there can be no doubt that in certain localities, such as in typical " trefoil country ", where a copious growth of wild clovers or medics regularly appears on the stubbles and fallows, considerable quantities of nitrogen are hereby supplied to the soil ; but these must still be regarded as unknown quantities, and we may safely assert that where growth of legumes is lacking or sparse, the cultivation of wheat is of a definitely exploitative character with regard to nitrogen.

A measure to counteract this general depletion of nitrogen naturally suggests itself in the introduction of leguminous crops in the cereal rotations The practice now sometimes adopted of laying down the wheat lands to lucerne or other forms of improved pasture should become *general* practice, subject of course to such modifications as the local conditions in each instance would necessitate. Rational experimental work in this direction should be regarded as a vital and a national necessity.

* This is not to say that the development of Azotobacter in the rhizosphere may not otherwise affect the growth of the plants ; for instance, by production of growth hormones as suggested by recent Russian investigations ; this, however, is a problem quite apart from that of nitrogen nutrition.

# A Successful Cross between *Triticum vulgare* and *Triticum timopheevi*

By

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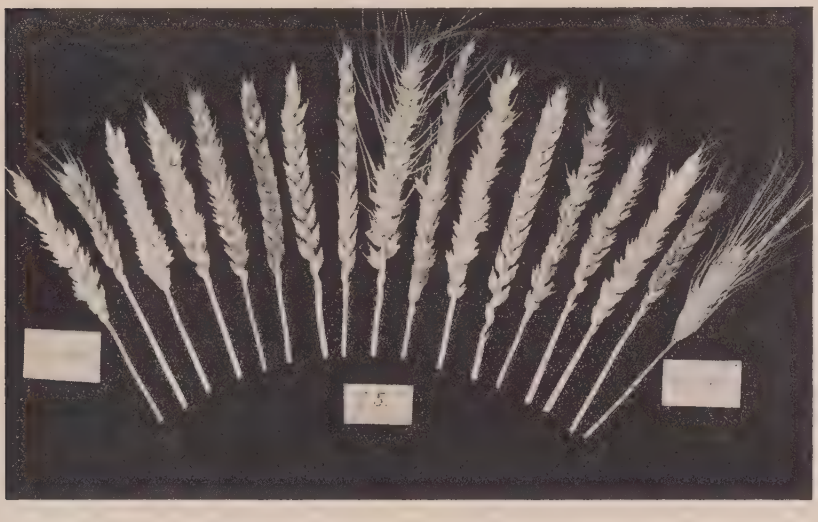
Plant breeders are continually searching for new sources of disease resistance. Even when parents resistant to a disease are available, there is always the possibility that this resistance may be broken down by the advent of a new physiologic form, or because of an alteration in one or other of several environmental factors. In some cases also resistance may prove to be associated or linked with undesirable characters which may necessitate the utilisation of a resistance derived from a different source.

Although, therefore, quite desirable parents, resistant to both stem rust (*Puccinia graminis tritici*) and leaf rust (*P. triticina*) of wheat are available in New South Wales, the species *Triticum timopheevi* (Zhuk.) was introduced from Russia in 1931 because of its reputed resistance to these and several other diseases.

A description of *T. timopheevi*, with mention of the characters which distinguish it from *T. dicoccoides* (Korn), has been recorded by Zhukovksy.[9]

A number of unsuccessful or sterile crosses between *T. timopheevi* and *T. vulgare* have been recorded by Katayama,[2] Kihara,[3] Sands and Waldron,[7] Pal,[6] and Kostoff.[4] Jukubziner[1] claimed a successful cross between these two species but failed to recover the resistance of the *T. timopheevi* parent. Sands[7] is reported by Clark to have obtained a small percentage of seed by backcrossing the self-sterile first generation plant of this cross, but the subsequent degree of fertility of the backcross is unknown to the author.

With the object of making use of the disease resistance of *T. timopheevi*, crosses were attempted between it and *T. vulgare* by the author in 1933. Steinwedel was selected as the female *vulgare* parent because of the fertility reported by Waterhouse[8] when the variety was crossed with the 14 chromosome wheat, Khapli Emmer. From approximately eighteen flowers of Steinwedel pollinated with *T. timopheevi*, seven grains were set. These, sown in 1934, produced almost completely sterile first generation plants, only twenty very pinched second generation seeds being harvested. The following year only two third generation seeds were selected therefrom, and one of these, designated C1, produced in 1936 several fourth generation plants carrying high resistance to both leaf and stem rust under moderately severe rust epidemic conditions at Cowra. Grown in 1938 under the most favourable conditions for both leaf and stem rust infection in the rust nursery at Glen Innes, several



*Heads of Steinwedel and Timopheevi Parents and the F5 Generation of the Cross.*

of these fifth generation lines were fixed for apparent immunity to both rusts. They were also of fair agronomic type and appeared to be typical *vulgare* wheats.

In view of the sterility encountered, the width of segregation observed, and the number of hybrid derivations resembling the *T. timopheevi* parent, there can be little doubt as to the validity of this cross, which promises to yield disease-resistant parental types of considerable value. It is not, as yet, known whether any of the hybrids are resistant to *Erysiphe graminis*, *Puccinia glumarum*, the smuts, frit fly, or wheat stem fly, to all of which *T. timopheevi* has been reported as resistant.

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# Plant Viruses*

## THE INFLUENCE OF RECENT KNOWLEDGE ON METHODS FOR THEIR CONTROL

By

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Of the more or less recent developments which may be expected to influence the search for control measures for virus diseases, the most important is the discovery that quite a number of viruses are proteins. This discovery has, of course, taken on a much wider interest. It ties up naturally with the chemistry of proteins and their *in vivo* synthesis, the nature of serological and immunological reactions, the mechanism of mutations, and the cause of the reactions which are characteristic of what we call living matter—to mention a few of the many ramifications. We hear a great deal these days about the classification of viruses, that is in respect to their position in the scheme of things. So that you might know where I stand, I have at various times committed myself in print to the concept of viruses as living molecules. Although I still think of them in terms of living molecules, I must confess that it does not seem to me to matter very much how we classify them ; it is their structure and properties that matter most.

Since the earlier work on tobacco mosaic virus at Princeton and Adelaide, a number of other plant and animal viruses have been isolated in a chemically pure state and have been found to be proteins also. Mainly through the excellent work of the Cambridge and Rothamsted workers, eight other plant viruses have been shown to be nucleo-proteins, namely the viruses of ordinary, enation and yellow tobacco mosaics, two cucumber mosaics, the S. and G. strains of potato X virus and tomato bushy stunt virus ; another in tobacco ringspot is also a protein, but has not been fully investigated. The bacteriophage isolated by Northrop, and two animal viruses (rabbit papilloma and equine encephalomyelitis) have also been shown to be proteins, although in the case of the animal viruses published evidence is not as complete as it is for the plant viruses.

An interesting point is that all the viruses which have been examined to any extent are nucleo-proteins.

The majority of the plant viruses isolated assume the paracrystalline state, the particles being arranged regularly in two dimensions only. But

* Paper read at a symposium on " Virus Diseases " at the Canberra meeting of the A.N.Z.A.A.S., January, 1939.

one virus—that of tomato bushy stunt—has been obtained by Bawden and Pirie in the form of true, three-dimensional crystals.

Tobacco mosaic virus has been subjected to careful X-ray analysis by Bernal, who draws two definite conclusions: firstly, " that the virus particle has an internal crystalline structure of great regularity ", and secondly, " that this structure is analogous to that of other crystalline proteins ". The virus particle contains no internal water; and the approximate molecular weight of the virus calculated by Bernal from his data is 41,000.

The other plant viruses examined fit in well with the picture obtained for tobacco mosaic, and their classification on the basis of the similarities and differences of their diffraction patterns is the same as that previously arrived at by the observations of botanists and serologists.

## Living Molecules.

The chemical composition and some of the physical properties of the viruses=and this X-ray work in particular=supply the most conclusive evidence of the nature of this group of viruses. But in addition the whole *in vitro* behaviour of these viruses is comparable with that of the recognised, so-called non-living proteins. Yet in the plant they behave as living things (if we may use the word " living " as a convenient way of comparing an object under discussion with other objects to which the term has long been applied).

If we make inter-comparisons between other proteins, enzymes, viruses and recognised micro-organisms, there seems to be no escape from the conclusion that over this range, so far as we know, there appear to be no essential differences between living and non-living things. Unless we choose to define the term " living " (and such a definition can only be an arbitrary one), there is no point in arguing about it. If in our ignorance we coin a word to denote an apparent difference which later we find is not real, then surely that word should be dropped, or if it still serves a useful purpose, its limitations should be recognised. Whether we regard the matter as of importance or not, let us at least keep an open mind.

Nevertheless, in the present transitional state in our terminology it will be convenient to use the term, but merely as a means of comparison with things of known characters. For these reasons I believe that the term " living molecule " best expresses the nature of a virus for the present.

The large viruses are presumably more highly organised than those which have been " crystallised ", but unless they can be shown to have a type of organisation and metabolism very much nearer that of bacteria and very different from the type virus, there would appear to be no point in making invidious distinctions. It may be that viruses are a first attempt at an unlimited self-reproductive unit, and may form a collateral branch rather than a direct line in the evolutionary scale.

In any case, the point for the time being is that proteins must be added to the list of infectious pathogenic principles, and that whatever else we might call them the pathologist has to make up his mind to fight proteins and their prosthetic groups.

Now a word or two about control measures.

Since so many of the economically important virus diseases are spread by insects, the entomologist's fight against these vectors will, of course, go on.

The search for disease-resistant varieties is an old practice which is as important today as ever.

From the point of view of virus control, however, I would like to draw attention to the fact that what is often termed resistance to disease is merely *tolerance*. A so-called resistant plant may, when infected with a certain virus, grow well and show no symptoms of the disease but may still carry the virus in large quantities. Provided that the *quality* of the plant product is not impaired, this may be no disadvantage but care should be taken to test for quality at an early stage in any investigations. In the case of tobacco, for example, the *Ambalema* variety is tolerant to tobacco mosaic and it has recently been shown that the virus still multiplies in the plant. We know from the work of Earl and his Sydney colleagues that smoking quality in Australian tobacco is related to the relative proportion of nitrogen and organic acids present in the leaf at maturity. Now one effect of mosaic virus infection of tobacco is to raise the total- and protein-nitrogen contents of the mature leaves above those of the healthy controls of the same age.

Some figures I obtained in a preliminary experiment carried out during the autumn of 1935 are summarised in Table I.

TABLE I.—*Protein Nitrogen and Total Nitrogen Content of Healthy and Mosaic Diseased* (Nicotiana *virus* 1) *Tobacco Leaves* (*var. Blue Pryor*) *at the beginning of the Flowering Stage.*
(Gm. N. per 100 gm. dry matter.)

| | Healthy Plants. | Mosaic Plants. |
|---|---|---|
| Total nitrogen— | | |
| Young leaves .. .. .. .. | 4·79 | 6·10 |
| Mature leaves .. .. .. | 1·78 | 5·17 |
| Protein nitrogen— | | |
| Young leaves .. .. .. .. | 4·41 | 5·38 |
| Mature leaves .. .. .. | 1·67 | 4·46 |

*Note.*—The extractable virus would account for about one-twentieth only of the protein nitrogen present.

It will be observed that both total nitrogen and protein nitrogen are higher in the mosaic diseased leaves. The difference in the case of the young leaves is not great, but in the case of the mature leaves there is a difference of between 200 and 300 per cent.; and only about five per cent. of this can be

due to the presence of extractable active virus. The effect that this extra protein may have on the quality of the leaf is evident. This is, I think, a point which should be tested and considered in a search for resistant varieties.

Another point is that even if all is well on this score, there is still the possibility that a virus which causes little damage to one host may be lethal to others, and we are always up against the possibility of a mutant arising which will be dangerous to the tolerant plant itself.

In the type of resistance I have just mentioned, the infection is systemic and the virus is still present throughout the plant. It is a resistance against damage rather than against invasion by the virus.

Some plants, on the other hand, have the power to localise the virus at the site of entry. Necrotic lesions are produced, and the affected leaf may drop off, but the virus does not spread to the rest of the plant. There is, of course, a gradation between the two types of response. The response is not always the same, and often depends on environmental conditions.

Holmes, at Princeton, is doing some very interesting work on the inheritance of the necrotic type response. Working with pepper and tobacco he has found that the power to localise the virus is inherited as a dominant Mendelian character. He has also accomplished an interspecific transfer of the gene responsible for this type of response. The possibilities which lie ahead of this technique as a means of raising disease-resistant varieties appear to be considerable, and no doubt geneticists will exploit them to the full.

### Protective Inoculation.

Another promising method has arisen out of the work of Salaman, Thung and others. This is the method known as protective or prophylactic inoculation. Quite a number of viruses exist in mild as well as virulent strains, and it was found that plants previously infected with the mild strain, which did very little damage, were more or less immune to the virulent strain. According to available evidence the mechanism by which this immunity is produced is not at all like that which operates in the case of animals. This difference is presumably due to the fundamental difference between the nature of the hosts and not to any essential difference between animal and plant viruses. Plant viruses, like other proteins, produce antibodies when injected into animals, but the existence of antibodies in plants is not yet proven. A mechanism suggested to account for the development of this type of immunity in plants is that the mild and virulent strains act on the same substrates, and therefore, once the mild strain has spread throughout the plant, there is little left for the virulent strain to act on and multiply. There is a very fascinating field of work here for botanical and chemical co-operative work. But whatever the explanation, the behaviour is of considerable importance from the point of view of possible control measures. The method has been successfully used by Thung with sugar cane in Java, and Salaman in England is having success

with it in combating potato X virus. Quanjer is also applying it to the potato crop in Holland.

Large scale protective* infection presents little difficulty with vegetatively propagated crops and there should be no great difficulties with other crops. At present we would be restricted to viruses for which harmless strains existed naturally, but there is here an interesting field for the chemist. When more is known about the structure of the virus protein molecules and the structional differences between virulent and mild strains, it should be possible to produce mild strains artificially in the laboratory by removing groups from, or introducing new groups into, the virulent strain. Of course, one would have to be careful not to let a particularly virulent new strain which might be produced get away, and the remarks I made about the tolerant varieties apply here also. In any case, fundamental work of this kind is bound to become a long range problem, and much more might be expected to result from it than the development of the protective infection method of control.

When the production of artificial climates becomes an economic proposition, the effects of temperature and light on some diseases may be exploited.

Kunkel has cured peach yellows in seedling trees by subjecting infected seedlings to air temperatures of about 36° C. for one month. The virus is inactivated in the living plant.

High temperatures also cause the inactivation of tomato spotted wilt virus in the tomato plant, and sunlight inhibits the spread of this virus in lesions on tobacco leaves.

### Incorporating Inactivating Substances.

The important thing about the control of virus diseases in plants is prevention. Speaking generally, once a virus has become established in a plant there is little hope of saving it. The idea of incorporating in the plant, by spraying or other means, something which will inactivate the virus at or near the seat of entry is an attractive one. But in view of the nature of viruses this method does not appear to be very hopeful unless something very specific for the particular protein is found.

To indicate the type of difficulty one is likely to meet, we might consider the case of tomato spotted wilt virus. One of the most characteristic properties of this virus is its ready inactivation *in vitro* by very dilute solutions ($10^{-4}$ M) of mild oxidising agents operating at and above a redox potential (at pH7) of about +0·15 volt (rH=19). Unfortunately it does not seem likely that the introduction of such substances into the plant will result in giving the desired protection. Those portions of the plant in which the virus multiplies must, in virtue of this very fact, have a net redox potential of such a value that the oxidising substances one would introduce would be reduced and so rendered

* This term, I think, describes the state of affairs more accurately than those in common use and is not open to misinterpretation.

inoperative. In the absence of oxygen, the expressed juice of the plant (admittedly a composite thing) reduces those oxidants which inactivate the virus. To kill the virus by this means as it enters the plant, it may be necessary to add more oxidants than the plant itself can tolerate. The whole of the normal oxido-reduction mechanisms which are so vital to the plant would be thrown out of gear. The difficulty is increased by the fact that viruses appear to spread in the plant by way of the vascular system, particularly through the phloem. I do not wish to suggest that this line of attack should be ruled out. I merely want to indicate the nature of the problem. In any case, we still know so little about the reactions of any virus that some newly discovered reaction or property might suggest a new line of attack. This is another reason why the long range fundamental work is so necessary from the point of view of control measures. And what may be discovered about one virus may be applied in principle to others.

But there is another possible line of attack in the case of those viruses which are inactivated at pH values near to that of the plant parts in which they operate. Tomato spotted wilt virus, for example, is inactivated rapidly at a pH value of 5·5 or less. This is also about the pH value of the expressed juice. The phloem contents have presumably a higher pH value, and there is reason to believe that the xylem contents have a lower one. The fact that the critical pH value for virus activity lies near to what we believe* to be the pH value of those portions of the plant in which the virus multiplies, suggests a possible method of control, that is, to grow plants in which low pH values prevail.

One possible method of doing this would be by suitable nutrition, but on the basis of existing knowledge this does not appear to be too hopeful. A better method, and one which should be well worth trying, is a matter for collaboration between chemist and geneticist. The first step would be to develop a reliable method of measuring intracellular pH values. This would be followed by a survey of existing varieties of plants on the basis of the pH values of their relevant parts. The geneticist could then co-operate with the chemist in an attempt to produce a variety with the desired internal environment.

The principle applies quite generally, of course, to other factors which may be correlated with the power of the plant to resist virus infection. The point I wish to make is that practical results may come from a combined attack by chemists, plant geneticists and plant anatomists. Also, a biochemical investigation of selected varieties of known differences in respect to susceptibility may well result in finding some factor or factors associated with resistance, which the geneticist is able to handle in breeding experiments; and the chemical tests would greatly expedite his work.

* From the pH value of the expressed sap and Small's approximate staining method.

In conclusion I would like to stress the point that virology, or the study of viruses, will be best advanced by collaborative and co-operative work between physicists, chemists and biologists, of all types. This is true whether we are concerned with the acquisition of knowledge *per se* or with its application. Viruses are borderline things which are so constituted that practically every kind of scientific technique not only can be profitably employed in their investigation, but *must* be employed if we are to arrive at a true evaluation of their nature and properties.

# TECHNICAL NOTES

## BACTERIOPHAGE IN A PURE STRAIN CULTURE OF *STREPTOCOCCUS CREMORIS* IN NEW SOUTH WALES.

Selected pure strain cultures of *Streptococcus cremoris* have been distributed to cheesemakers by the N.S.W. Department of Agriculture since 1926. Such " starters " have a very favourable effect on the texture of the curd and produce acid at a rate which remains practically constant from day to day.

An occasional unpredictable failure of acid formation either in the bulk starter or in the manufacturing vat has been the one factor which has seriously detracted from the complete success of the single strain culture. The nature of these failures was first investigated by Whitehead and Cox[1] in New Zealand, and was shown to be due to the activity of bacteriophage. The researches of Whitehead and Cox and Whitehead and Hunter have established that it is practically impossible to propagate pure strain starters under factory conditions without the appearance, sooner or later, of bacteriophage specific or nearly specific to the particular strain of *S. cremoris* being used.

Although, in New South Wales, presumptive tests which consisted of mixing various cultures of one strain had strongly suggested the presence of bacteriophage and the existence of cultures susceptible or resistant to the 'phage, no definite attempt to isolate the active principle was made prior to November, 1938. In November, samples of whey were obtained from all the chief factories in this State and were carefully examined for the presence of bacteriophage active against strain Sur I. No 'phage was found in any of the samples.

A sample of whey was collected from a cheese factory at Frederickton in February of this year. When tested by the plate-smear technique it exhibted no ability to cause plaque formation. However, an enrichment treatment in

milk culture was effective in producing the bacteriophage in demonstrable quantities. The enrichment was obtained by inoculating 5 gallons of " sterilised " skim milk with 20 ml. of starter and 18 ml. of the whey which had been passed through a Seitz filter (grade EK). The milk fermented and coagulated in a normal manner but 2 ml. of the whey which exuded from the curd was added, after filtration, to 8 ozs. of sterile skim milk and 12 drops of starter. Although this culture also coagulated in normal time, a sample of the resultant whey caused lysed areas to develop on smeared agar plates and brought about the disintegration of cells of the Streptococcus growing in milk culture.

The strain of bacteriophage isolated is only partially destructive of the total cell population of starter Sur I—which was the organism used in the 'phage enrichment process. Though numerous attempts have been made to produce a whey with a high 'phage titre it has so far been impossible to obtain plaque formation with dilutions greater than $10^{-5}$. Individual plaques are rather hard to locate as they are extremely minute.

Although it has been impossible to bring about a complete breakdown of all the cells in milk culture, the reaction to the presence of the 'phage is quite obvious. Whereas a normal culture of Sur I forms fairly long chains of box-shaped cells, the chains in 'phage-treated cultures become much shorter and may break down to diplococci or even to single cells. Another reaction is the formation of aggregations of twenty or more cells of enlarged, distorted appearance into tightly packed irregular bundles.

In its major characteristics this bacteriophage seems to be identical with a culture obtained from Dr. Whitehead. This latter culture was isolated in New Zealand from a commercial vat of cheese in which Sur I had been used as a starter.

It has been observed in this laboratory that both the New South Wales and the New Zealand strains of bacteriophage destroy or distort the majority of the cells in the culture, but seldom delay the coagulation of the starter beyond 24 hours from the time of inoculation. This fact and the ability of 'phaged cultures in general to generate resistant cells may explain the infrequent occurrence of total failures of acid development in vats of cheese manufactured from milk treated with Sur I as a starter.

W. S. Sutton.

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## References.

(1) Whitehead, H. R., and Cox, G. A. J. Dairy Res., 7 : 55-62, 1936.
(2) Whitehead, H. R., and Hunter, G. J. E. J. Path. and Bact., 44 : 337-347, 1937.

## ASSOCIATION OF SULPHATE REDUCTION IN THE SOIL WITH ANAEROBIC IRON CORROSION.

The tendency of iron to corrode under anaerobic conditions in heavy clay or waterlogged soils has been frequently observed, and investigations into the associated factors have been stimulated by the economic considerations involved. This type of corrosion has well defined characteristics and is commonly referred to as " graphitisation ", owing to the superficial resemblance of the structure of the affected iron to graphite.

Instances of anaerobic corrosion affecting gas mains in Sydney have recently been brought under the notice of the writer, and in all cases the typical associated conditions have been recognised. The mains assume a porous and brittle structure, and are generally found to be encased in a layer of black mud of about half an inch in thickness. Chemical analyses of the soil in the neighbourhood of affected pipes reveal a high concentration of sulphides and a low concentration of sulphates as compared with soil at some distance away. Large numbers of typical sulphate-reducing bacteria are invariably present in the soil adjacent to the corroded areas.

The constant association of sulphate reducing bacteria with graphitisation suggests that the phenomenon is a function of their activity. A biological theory of the process was originally promulgated by van Wolzogen Kuhr and van der Vlugt,[3] and it has been supported by the recent extensive investigations of Bunker.[1] The ordinary corrosion of iron is an electro-chemical reaction in which iron goes into solution at levels of positive potential whilst hydrogen is liberated as hydrogen ions at cathodic points. Where free oxygen is available, the hydrogen combines to form water and the reaction proceeds until rusting is complete. Under anaerobic conditions, however, there is an accumulation of hydrogen ions and a condition of polarisation is set up, resulting in the cessation of the corrosive process. If a mechanism is available for the removal of the hydrogen ions, corrosion will proceed in the absence of free oxygen.

It is believed that the biological process of sulphate reduction provides this mechanism. The conversion of sulphates to sulphides results in the freeing of oxygen which is normally available for the oxidation of carbohydrates and other organic compounds. Under the conditions which bring about graphitisation, the energy requirements of the sulphate reducing bacteria are satisfied by the combination of the liberated oxygen with the hydrogen freed in the electro-chemical decomposition of the iron. The two reactions are thus seen to be complementary. The iron going into solution reacts with the sulphides, giving the characteristic black colour to the soil immediately surrounding the pipe itself. The series of reactions initiated in this way proceeds to completion with the entire replacement of the metallic structure

of the pipe by the typical soft graphitised condition which appears to be a mixture of various oxides of iron.

Experiments carried out in this laboratory support this general theory. It has been observed that when sulphate reducing organisms are inoculated into a medium containing sulphates and ammonium salts alone, no growth occurs. When either a suitable organic compound such as sodium lactate or finely divided iron in the form of the steel wool commonly used for scouring purposes is introduced, $H_2S$ production is promptly initiated. Under the latter circumstances the sulphate reducing organisms are apparently capable of an independent autotrophic existence, which is not in accordance with previous conceptions of their physiological requirements. Waksman[2] states, for instance, that amongst other factors the presence of organic compounds as sources of energy is necessary for sulphate reduction by *Microspira desulfuricans*. Apart from experimental evidence, however, the capacity of these organisms for extensive development adjacent to iron in deep clay subsoils where the concentration of organic compounds would be negligible, suggests that they are not strictly heterotrophic.

EDWIN G. PONT.

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Sydney, N.S.W.

## References.

[1] Bunker, H. J. Fifth Report of the Corrosion Committee, Sect. F, Part 3, Iron and Steel Inst., 1938, p. 431.

[2] Waksman, S. A. Principles of Soil Microbiology, 1927, p. 612.

[3] von Wolzogen Kuhr and van der Vlugt. Water, Vol. 18, 1934, p. 147.

# The Australian Institute of Agricultural Science

## MEETINGS OF COUNCIL.

### June Meeting.

Held in the School of Agriculture, Melbourne University, on June 1st, 1939, at 7.30 p.m. Present: Mr. W. B. Miller (V.) (in chair), Messrs. J. L. Gillespie (N.S.W.), G. W. Leeper (A.C.T.), Dr. A. E. V. Richardson (S.A.), Dr. H. C. Forster (W.A.), the Hon. Treasurer, Mr. R. L. Twentyman, the Hon. Secretary, Mr. A. J. Vasey, and the Assistant Hon. Secretary, Mr. R. D. Croll. Apologies were received from Messrs. H. J. Geddes (T.) and P. S. Lang (Q.).

The Tasmanian delegate reported that the Tasmanian Branch considered that greater publicity for the Institute was desirable and that press notices, public meetings and the undertaking of specific projects would assist in this direction. Small and scattered membership of the Tasmanian Branch made the undertaking of any large projects rather difficult.

Dr. Richardson (S.A.) reported that the S.A. examination of the Branch reports showed that there were three forms of gatherings adopted in other States that the Committee thought might be successful in S.A. These were public or semi-public gatherings, meetings with notes and exhibits and luncheons for distinguished visitors.

Mr. Miller (V.) said that the Victorian Branch noted with approval the idea of holding exhibit nights as adopted by the Queensland Branch, and it further suggested that a night might be devoted with profit to a discussion of the matters raised in each issue of the Journal. The Victorian Branch also considered worthy of adoption the practice of holding luncheons for distinguished people, as followed by the W.A. Branch.

The following were admitted to membership:

*To Corporate Membership:* E. J. Johnston (S.A.), J. L. Schofield (Q.), Miss A. Nicholls (Vic.), W. D. Andrew (Vic.), G. R. W. Meadly (W.A.), K. R. Norris (W.A.), G. N. Lowe (W.A.), J. Conochie (W.A.).

*To Student Membership:* N. S. Tiver (S.A.), C. E. Haines (S.A.), H. T. Hughes (S.A.), R. M. Baker (S.A.), A. J. Millington (W.A.), D. B. Williams (N.S.W.), B. O. Brench (N.S.W.), J. H. Taylor (N.S.W.), N. C. Lloyd (N.S.W.), S. M. Sykes (N.S.W.), K. O. Campbell (N.S.W.), C. H. Macphellamy (N.S.W.).

The Council decided that its congratulations should be forwarded to the following: Dr. J. W. Evans (Tas.) and Dr. C. J. Magee (N.S.W.) on their respective admissions to the D.Sc. and D.Sc.Agr. degrees, and to Mr. C. M. Donald (S.A.) on the award to him of the Pawlett Travelling Scholarship of the University of Sydney.

The Treasurer's financial statement showed a balance at bank on June 1st of £110 19s. 9d.

### July Meeting.

Held in the School of Agriculture, Melbourne University, on July 11th, 1939, at 8 p.m. Present: Mr. W. B. Miller (V.) (in chair), Messrs. J. L. Gillespie (N.S.W.), G. W. Leeper (A.C.T.), H. J. Geddes (T.), P. S. Lang (Q.), Dr. H. C. Forster (W.A.), the Hon. Treasurer, Mr. R. L. Twentyman, the Hon. Secretary, Mr. A. J. Vasey, and the Assistant Hon. Secretary, Mr. R. D. Croll. An apology was received from Dr. A. E. V. Richardson (S.A.). Mr. Miller spoke with deep regret of the loss occasioned to the Institute by the death of Mr. A. C. Drevermann (V.).

Proxies communicated the views of their respective principals in regard to the request of the Victorian Branch for approval for the expenditure from Institute funds of a sum (£11 16s.) required for the purchase of maps for use in connection with the potentialities survey. Branches were not unanimous that the grant be made, and after lengthy discussion the meeting decided to submit for the consideration of principal delegates and decision at next meeting, the following recommendations:

1. That on the receipt of the Hon. Treasurer's report in December of each year, the Council should declare a *per capita* rebate to Branches, which would be payable early in the new year, i.e. an interim dividend. (*N.B.*—This method is the one at present in operation.)

2. That on receipt of the auditor's report in respect of any year's operations (usually received in the following May) the Council should determine what proportion of the declared surplus, if any, should be placed in reserve and what amount was available for a further distribution to Branches on a *per capita* basis, i.e. a final dividend.

3. That in respect of the year 1938 the sum of £52 19s. 9d., shown as surplus in the auditor's report, should be distributed to Branches as the additional *per capita* grant.

The following were admitted to membership:

*To Corporate Membership:* A. W. S. May (Q.), E. E. Henty (Vic.), J. K. McK. Skene (Vic.), H. L. Hore (Vic.), F. A. Maher (Vic.), J. C. Walsh (Vic.), R. H. Beattie (Vic.), S. C. Powell (Vic.), A. W. Stewart (Vic.), E. J. Wason (N.S.W.), R. R. Pennefather (N.S.W.), W. A. Horsley.

*To Student Membership:* J. S. Collings (N.S.W.), L. R. Hoult (Vic.), L. J. Swaby (Vic.), G. M. E. Mayo (S.A.).

Following advice received from solicitors *re* proposed amendment of Article 63 of the Articles of Association, the Council decided that notice should be hereby given that it was proposed that Article 63 of the Articles of Association of the Institute be amended by deletion therefrom of the words " other than that of which the Sub-Editor is a member ".

The Treasurer's financial statement showed a balance at bank on July 11th of £127 2s. 10d.

Details of the position of Superintendent of Agriculture in the Northern Territory were circulated to members of the Council and discussion followed. On the motion of Mr. Gillespie (N.S.W.), seconded by Mr. Geddes (T.), the Hon. Secretary was directed to write to the Department of the Interior on behalf of the Institute, protesting against the salary range offered (£504-£576, with allowance of £20 per annum for married employee) and suggesting that the men who would probably be attracted by this poor remuneration would be unlikely to develop the Territory as desired.

The Council directed that its congratulations should be forwarded to Dr. G. A. Currie in respect of his appointment to the Hackett Chair of Agriculture in the University of Western Australia.

## MEETINGS OF BRANCHES.

### Canberra Branch.

The annual dinner and general meeting were held on May 25th. The following were elected as office-bearers for 1939-40: President, Dr. I. M. Mackerras; Hon. Secretary and Treasurer, Mr. A. V. Hill; Hon. Sub-Editor, Dr. W. V. Ludbrook; Committee, Drs. H. R. Angell, G. A. Currie, B. T. Dickson and J. R. A. McMillan (Dr. Currie subsequently resigned and was replaced by Mr. F. N. Ratcliffe); Hon. Auditors, Miss F. E. Allan and Mr. E. Mackinnon. The present membership of the Branch is 31. There was a general discussion on the function of agricultural research workers in a national emergency. In opening the discussion, Dr. Dickson illustrated the waste of effort in the last war by failure

to utilise men in accordance with their special ability and training. Some members considered that the Institute could play a helpful part in organising and advising with regard to agricultural products, while others felt that this was more properly the function of governmental organisations.

A meeting held on June 14th was addressed by Mr. W. J. Spafford (Director of Agriculture, South Australia) on " Agricultural Production in South America ". He pointed out that South America, especially the Argentine, was of far greater potential significance as an agricultural rival to Australia than our other competitors on the world's markets. Mr. J. Harrison, Agrostologist of Australian Estates Ltd., spoke on " Pasture Management in the Western District of Victoria ". He emphasised the need for highly trained extension workers, and suggested that an excellent method by which they could gain experience would be to spend a number of years on detailed surveys of district production.

## New South Wales Branch.

The general meeting held on May 19th at Science House, Sydney, was attended by 29 members. Preliminary reports were presented by the sub-committees appointed to investigate the various Institute projects. The main business was a discussion led by Mr. W. Tearle entitled " Soil Science in Relation to Agricultural Education ". Following a most interesting discussion a sub-committee was appointed to investigate the possibilities of drawing agricultural teachers into closer contact with research work. The personnel of the committee is as follows : Messrs. E. E. Breakwell, E. L. Griffiths, A. W. S. Moodie, J. M. Vincent, W. Tearle, S. Cook and the Hon. Secretary (Mr. H. P. Brown).

At the July meeting, the Honorary Secretary presented a very complete report of the sub-committee on " Salaries and Status ". The main business was an address by Mr. J M. Vincent entitled " The Significance of Bacteriology to Agriculture ". This was followed by a discussion led by an excellent dissertation on soil bacteriology given by Mr. H. L. Jensen, Macleay Bacteriologist of the Linnean Society of N.S.W.

## Victorian Branch.

The establishment of the Institute before the general public received a further impetus as the result of a successful meeting held by the Victorian Branch on August 1st, at 8 p.m., to discuss the question " Can wool hold its place in the textile world ? " The meeting was held in the Union House Theatre at the University of Melbourne, and was attended by 60 members of the A.I.A.S. and 340 invited guests, including representatives of the following organisations and personal friends of members : C.S.I.R., Department of Agriculture, Graziers' Association of Victoria, Veterinary Association of Victoria, Chamber of Manufacturers, Associated Woollen and Worsted Textile Manufacturers of Australia, Melbourne and Geelong Wool Brokers' Associations, Victorian Wool Buyers' Association, Society of Dyers and Colourists of Australia (Victorian Branch), Economic Society of Australia and N.Z. (Victorian Branch), Institute of Public Administration, and the Melbourne University Agriculture and Commerce Societies.

The meeting was one of the largest and most representative gatherings of people associated with and interested in scientific agriculture ever held in Melbourne. The meeting demonstrated the value and effectiveness of the Institute as an organizing medium for inspiring thought and discussion on important problems connected with the agricultural welfare of the community, and its success will encourage the Victorian Branch to hold similar meetings in the future as opportunity occurs.

The chairman was Mr. W. B. Miller, M.Agr.Sc., President of the Victorian Branch of the A.I.A.S., and the main speakers were Sir Dalziel Kelly, Chairman of the Australian Wool Board, and Martin R. Freney, B.Sc., Research Officer, McMaster Animal Health Laboratory, Sydney.

## THE AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE.

### Income and Expenditure Account for Year Ended 31st December, 1938.

| 1937 £ s. d. | EXPENDITURE. | £ s. d. | £ s. d. |
|---|---|---|---|
| 158 5 2 | To Cost of Journal | | 140 18 8 |
| 5 18 3 | ,, Printing and Stationery | | 38 12 3 |
| 33 11 3 | ,, Annual Meeting Expenses | | — |
| — | ,, Incorporation Expenses | | 55 15 6 |
| 4 7 0 | ,, Incidentals | | 3 5 9 |
| 5 5 0 | ,, Audit and Accountancy Fees | | 8 8 0 |
| 3 14 1 | ,, Petty Cash | | 10 16 7 |
| | ,, Grants to Branches— | | |
| 23 18 6 | New South Wales | 25 0 6 | |
| 20 18 0 | Victoria | 28 17 6 | |
| 13 4 0 | South Australia | 14 6 0 | |
| 12 7 6 | Queensland | 12 7 6 | |
| 8 16 0 | Western Australia | 13 4 0 | |
| 7 19 6 | Australian Capital Territory | 7 14 0 | |
| 4 2 6 | Tasmania | 5 10 0 | |
| | | | 106 19 6 |
| 302 6 9 | ,, Total Expenditure | | 364 16 3 |
| 56 16 3 | ,, Surplus for Year | | 52 19 9 |
| £359 3 0 | | | £417 16 0 |

| 1937 £ s. d. | INCOME. | £ s. d. | £ s. d. |
|---|---|---|---|
| | By New South Wales Branch, Subscriptions— | | |
| | Arrears | 6 6 0 | |
| | Current | 90 0 0 | |
| 91 7 0 | | | 96 6 0 |
| | ,, Victorian Branch, Subscriptions— | | |
| | Arrears | 11 11 0 | |
| | Current | 98 19 0 | |
| 82 1 0 | | | 110 10 0 |
| | ,, South Australian Branch, Subscriptions— | | |
| | Arrears | 3 3 0 | |
| | Current | 52 4 0 | |
| 51 13 0 | | | 55 7 0 |
| | ,, Queensland Branch, Subscriptions— | | |
| | Arrears | 2 2 0 | |
| | Current | 45 18 0 | |
| 48 10 0 | | | 48 0 0 |
| | ,, Western Australian Branch, Subscriptions— | | |
| | Arrears | 6 6 0 | |
| | Current | 45 12 0 | |
| 35 12 0 | | | 51 18 0 |
| 30 9 0 | ,, Australian Capital Territory Branch, Subscriptions—Current | | 29 8 0 |
| | ,, Tasmanian Branch, Subscriptions— | | |
| | Arrears | 3 3 0 | |
| | Current | 17 17 0 | |
| 15 15 0 | | | 21 0 0 |
| | ,, Overseas Subscriptions— | | |
| | Arrears | 0 15 6 | |
| | Current | 0 15 6 | |
| 2 12 0 | | | 1 11 0 |
| 1 4 0 | ,, Interest | | 3 16 0 |
| £359 3 0 | | | £417 16 0 |

### Balance Sheet as at 31st December, 1938.

| 1937 £ s. d. | LIABILITIES. | £ s. d. | £ s. d. |
|---|---|---|---|
| | Sundry Creditors— | | |
| 91 17 0 | Branch Grants | 123 4 0 | |
| 14 7 0 | General | 21 3 3 | |
| | | | 144 7 3 |
| 1 1 0 | Subscriptions Paid in Advance | | 4 4 0 |
| | Accumulated Fund—Balance at 1/1/1938 | 250 12 3 | |
| | *Add* Surplus for Year to 31/12/1938 | 52 19 9 | |
| 250 12 3 | | | 303 12 0 |
| £357 17 3 | | | £452 3 3 |

| 1937 £ s. d. | ASSETS. | £ s. d. | £ s. d. |
|---|---|---|---|
| 6 10 0 | Office Furniture—Sydney | | 6 10 0 |
| | Cash at Bank— | | |
| 168 10 4 | Melbourne | 187 5 8 | |
| 15 2 3 | Sydney | 17 3 7 | |
| | | | 204 9 3 |
| 100 0 0 | Fixed Deposits | 200 0 0 | |
| 1 4 0 | Fixed Deposits Accrued Interest | 2 5 0 | |
| | | | 202 5 0 |
| 63 5 0 | Subscriptions Outstanding (since collected) | | 37 10 0 |
| 3 5 8 | Petty Cash on Hand | | 1 9 0 |
| £357 17 3 | | | £452 3 3 |

These are the Statements referred to in our Report dated 24th May, 1939.

CLEVELAND, SON & HISLOP,
Chartered Accountants (Aust.).

## South Australian Branch.

A meeting was held on July 22nd, when Mr. J. N. McGilp, a member of the Pastoral Board and the State Committee on Soil Erosion, gave an address on " The Past History, Present Position and Possible Future of the Pastoral Lands of South Australia ". Forty-four visitors, representative of pastoral and banking interests, were present by invitation.

Mr. McGilp pointed out that the South Australian pastoral lands fell naturally into three groups : the grasslands inside or south of Goyder's Line, the saltbush country north of that, and, further north from a line about Farina, the Mitchell grass country which was devoted to cattle raising. In the past, the saltbush country had been regarded as the main pastoral land carrying well over 50 per cent. of the State's sheep population.

The deterioration of these lands, which was amply illustrated by photographs, coupled with grassland improvement in the better rainfall areas, had resulted in a southerly shift in the density of sheep population.

Discussing the causes of this deterioration, stress was placed on the evils of overstocking and the depredations of rabbits in an arid environment. In dealing with the question of aridity in this area, Mr. McGilp considered that it had been aggravated by a failure in the ability of the central rivers to discharge their waters into the large salt lakes of the interior, Lakes Eyre and Frome.

## Queensland Branch.

The meeting arranged for April was postponed until May 4th in order to link with Professor J. A. Prescott's visit to the State. A large body of members enjoyed his address on " Soil Deficiencies in Minor Elements ". This was of considerable interest, due to the wide scope of the principal subject that was discussed and also because of the inner history of the various stages in certain of the research work that led to the realisation of the importance of minor element deficiencies.

Another meeting in May took the form of a motion picture display, featuring principally the Queensland sugar industry.

On June 30th the business comprised notes and exhibits on current topics. Mr. P. J. Skerman exhibited (1) a stalk of Co. 290 variety of sugar-cane showing twinning, reported to be prevalent in the Bundaberg district, and (2) a culture plate of a bacteriophage isolated from a Lockyer soil, possibly the agent responsible for poor nodulation of lucerne in the Lockyer Valley. Mr. L. G. Vallance showed graphs demonstrating the changes in pH of soils of the north coast pineapple areas, and the seasonal incidence of rainfall and the degree of evaporation. On behalf of Mr. H. K. Lewcock, Mr. Vallance exhibited pineapple plants showing zinc deficiency symptoms comprising chlorosis, rosetting, crinkling of leaves, and screwing of the growing points in the heart ; the leaves eventually become tough and dry. The trouble is corrected by applying zinc sulphate as a spray or in the fertiliser. Mr. S. T. Blake exhibited (1) specimens of Kikuyu grass in flower, and stated that he had observed flowering in various parts of Queensland and at various elevations and (2) native sand-binding grasses, including *Spinifex paradoxus* and *Plagiosetum refractum*, which should not be overlooked in the search for sand-binding species. All present took part in discussions on the exhibits.

The July meeting was of a more formal nature, when discussion centred round the two Institute projects of plant quarantine organisation and the agricultural potentialities and population capacity survey. Reports of sub-committees were received and agreement was reached on certain lines of action.

### Western Australian Branch.

At a general meeting held on June 2nd, Dr. E. J. Underwood gave a very interesting address entitled " Impressions of Agricultural Science Abroad ". Dr. Underwood returned last year after spending two years in America, Great Britain and South Africa under a Commonwealth Fund Fellowship. An idea of the types of fundamental research being undertaken in U.S.A. was gained from his remarks on projects such as those at Missouri on the physiology and biochemistry of milk secretion and on artificial insemination, and, at Columbia University, New York, on intermediary reactions in the body, using heavy isotopes. Dr. Underwood also emphasised the valuable work being done in agricultural economics and rural sociology, and made a strong plea for a considerable extension of such studies in Australia.

On July 19th, Dr. B. T. Dickson addressed the Branch on " The Work of the Division of Plant Industry, C.S.I.R."

### Tasmanian Branch.

The first meeting for the year was held on May 5th, when Mr. W. M. Carne gave an interesting address on " Fruit Juices " with special reference to the recently developed " Flash " process and its possibilities of adoption on a general scale in Australia. There was a full attendance of members.

The second meeting was held on June 16th, and this took the form of a conference with the Deputy Commonwealth Statistician (Mr. Exley) and members of his staff in regard to the collection and presentation of data connected with primary production. Many items were discussed and amendments suggested with a view to closer cooperation.

## Current Notes and News

### Professor G. A. Currie.

Dr. G. A. Currie, Officer-in-Charge and Principal Research Officer of the Weeds Investigation Section of the Divisions of Plant Industry and Economic Entomology, C.S.I.R., has been appointed to the Hackett Chair of Agriculture in the University of Western Australia.

Dr. Currie, who is 42 years of age, was born in Scotland. During the war he was on active service from 1915 to 1918. He graduated at the University of Aberdeen as Bachelor of Science with special distinction, and later obtained the B.Sc.Agr. degree. In April, 1936, he obtained his D.Sc. from the same University. Sixteen years ago, he came to Australia and for three years served as manager for a company concerned with tropical agriculture at Koumala, near Mackay, in Queensland. For nearly a year he was assistant to the Commonwealth Cotton Entomologist, and in 1927 was appointed Assistant Entomologist in the Queensland Department of Agriculture. Two years later he joined the C.S.I.R. as Officer-in-Charge of the Weeds Section, and since that time many notable contributions have been made to our knowledge of the nature and control of the major weed pests.

In 1937, Dr. Currie visited several overseas countries and gained first-hand experience on problems in pasture management and weed control. As Secretary for the A.N.Z.A.A.S. in Canberra, he was mainly responsible for the very successful Jubilee meeting of that Association in the Federal City last January.

## Doctorates Conferred.

Mr. J. Calvert, M.Sc., Plant Physiologist, Division of Plant Industry, C.S.I.R., Canberra, received the degree of Doctor of Science of Queen's University, Belfast, *in absentia*, on July 7th, 1939. His thesis was entitled " Some Observations on Australian Crop Plants ". Dr. Calvert has been engaged in studies of the physiological aspects of drought resistance in cereals, and has recently begun work on fibre plants.

Advice has been received that Mr. L. C. Snook, an honours graduate in agriculture of the University of Western Australia, has been awarded the degree of Doctor of Science of the University of Aberdeen for a thesis on " The Effect of Diet on Ketonemia and Pregnancy Disease in Breeding Ewes ". The work was carried out at the Rowett Institute.

Mr. E. T. Edwards, M.Sc.Agr., was admitted to the Ph.D. degree, Wisconsin, in June, for a thesis dealing with certain aspects of Fusarium and Gibberella diseases of maize. Dr. Edwards, who is a plant pathologist in the N.S.W. Department of Agriculture, proceeded to U.S.A. in 1937 as Commonwealth Fund Service Fellow to undertake advanced study and research at the University of Wisconsin. He is expected to resume duties at the N.S.W. Department in October.

## Agricultural Sciences Club, S.A.

At the meeting held on May 25th, addresses were given by Mr. D. B. Adam on a " Gummosis " disease in South Australian apricots, and by Mr. F. H. Hooper on " Sherry ". Mr. Adam, in the course of his talk, which included a brief description of the principal symptoms and the life history of the causal fungus so far as it is known, drew special attention to the present known distribution of the disease which seemed to be significant. In South Australia, the disease was much commoner in the non-irrigated than in the irrigated apricot-growing areas. Outside of South Australia, Tasmania was the only place where the disease was definitely known to occur. Here too, apricots were grown under comparatively dry conditions without irrigation.

Mr. Hooper indicated the importance of sherry in world trade and rapidly surveyed the Spanish methods of production. In this production, film-forming yeasts constituting the " sherry flor " are obviously important. The establishment and maintenance of this " flor " in regions other than those where it has developed naturally have presented many difficulties, and indications were given of the lines along which this problem is being tackled.

At the July meeting, two papers were read and an exhibit shown. Mr. T. J. Marshall spoke on the movement of water in water-unsaturated soils. An apparatus was described for maintaining a given degree of water unsaturation in a soil for a sufficient length of time to enable the measurement of water passing through it at a steady rate. Permeability was shown to fall off rapidly with decreasing water content. The implications of this for cultural practice, plant wilting and the movement of water in the field were discussed.

Mr. H. K. Kemp discussed the " small prune problem " in South Australia. The problem as it occurred in the non-irrigated areas could be analysed in terms of annual rainfall. In regions where rainfall was between 20 and 25 inches, pruning practice was an important element contributing to size. In areas enjoying less than 20 inches rainfall, sheer lack of moisture generally proved a limiting factor. Where the rainfall exceeded 25 inches, the incidence of prune rust and of insect pests and factors of soil fertility assumed importance in determining prune size.

Mr. V. A. Stephen demonstrated a portable evaporimeter, the design of which had been evolved at the Waite Institute. Evaporation took place from a surface of 7·5 square inches which was automatically maintained at a constant level from a calibrated reservoir.

## Paper Making from Australian Hardwood.

On 30th June, Mr. O. H. Gepp addressed the Melbourne University Agricultural Society on " Practical Paper Making from Australian Hardwood ". Dividing his talk into two sections, paper making from pulp and pulp making, Mr. Gepp stated that paper making was one of Australia's main industries. Wood pulp was replacing rags, straw, esparto grass, etc., and was imported here as " lap " or partially disintegrated fibre sheets. On arrival, the lap must be disintegrated and then beaten, and in this latter process lies the art of paper making. Mechanical pulp was used mainly as newsprint, a weak paper, while in chemical pulping the wood was always chipped first and then either the sulphite, soda or kraft (i.e. sulphate) process used for digestion. Eucalypt fibre, in which the length to breadth radio is low, usually was blended with longer imported fibres such as spruce or hemlock. The development of a home source of long fibre, in Mr. Gepp's opinion, was of paramount importance. Following the discussion a talking film, " Logging in the North-West of the United States ", was shown.

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# Book Review

### REPORT ON AGRICULTURAL RESEARCH IN GREAT BRITAIN, by the Research Group of P E P.

(*Pp.* 154 *with map and statistical tables. London : P E P* (*Political and Economic Planning*) 1938. *Price,* 8/6.)

P E P (Political and Economic Planning) is an independent non-party group in Britain, consisting of more than a hundred working members—civil servants, scientists, economists, doctors, industrialists, etc.—who " give part of their spare time to the use of their special training in fact-finding and in suggesting principles and possible advances over a wide range of social and economic activities ". The group has already issued reports on such varied subjects as " The British Press ", the " British Health Services ", the " British Social Services " and " International Trade ", approaching each with the independence and detachment usually associated with a Royal Commission. It is, therefore, interesting and cheering to find that they have nothing but praise for the value of agricultural research to the farming industry and, indirectly, to the whole community, and that their recommendations are mainly in the direction of filling up the gaps in the system and extending it in certain directions. They have naturally some criticism of the machinery for research and extension, which has grown up in somewhat haphazard fashion ; and some useful comparisons, which could have been multiplied, are made with Denmark and the United States..

Some of the interesting facts elucidated are as follows : The actual research is carried out at about 50 different institutions, some of which are primarily educational in purpose with research as a by-product, while about 28 are research institutes proper where research is the paramount consideration. About 90 per cent. of the expenditure on agricultural research, including advisory work, in State-aided institutions is defrayed from national funds. The expenditure on agricultural research in Great Britain is still considerably less than 1 per cent. of the total output from the land.

They consider that the greatest weakness of the whole system is connected with the translation of the results of research into agricultural practice, and they point out that the chief drawback on the advisory side is that the initiative at present lies very largely with

the farmer, so that the backward farmers who most need the advice of the organiser rarely ask for it. They recommend more farm visits and field demonstrations and greater use of broadcasting, the cinema and popular articles in the Press with a central organisation to co-ordinate the whole of the extension work. Two other shortcomings emphasised are that the remuneration offered to the research worker is too low to attract an adequate number of able men or even to hold the more enterprising of those who choose the career, and the comparative neglect of scientific training in the schools. Many of the facts elucidated have a close parallel in Australia and we would do well to ponder over such a statement as this : " Civilisation based on technical discoveries demands that all children in rural schools should be taught the elementary principles of science ".

R. D. Watt.

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# Personal Notes

It is with deep regret that we record the death in England last month of Mr. Stanley Garthside, who had been stationed in Great Britain for several years as an entomologist of the C.S.I.R. His death was due to drowning while attempting to rescue another bather who was caught in an undercurrent. Mr. Garthside was to have returned to Australia in November to join the C.S.I.R. staff at Canberra. He had a distinguished record in agricultural science at Sydney University, and rendered valuable service in connection with the collection and breeding of insect parasites for control of weed pests.

Mr. S. L. Macindoe, Commonwealth Fund Service Fellow, was entertained by the Wheat Advisory Standing Committee and the Grain Trade Section of the N.S.W. Chamber of Commerce last month, prior to his departure for the University of Minnesota, U.S.A.

Mr. G. H. Burvill, of the W.A. Department of Agriculture, has been admitted to the M.Sc.Agr. degree, Adelaide.

Mr. F. W. Hely has been granted leave of absence from the Section of Genetics, C.S.I.R., during his tenure of a Commonwealth Research Grant Fellowship at Sydney University, where he is working on methods of hybridization of *Medicago* spp. Mr. W. M. Willoughby, formerly of the same Section, is now with the Weeds Section and has been stationed at Lawes, Queensland.

Mr. H. K. C. Mair, formerly of Canberra, has resigned his position as Superintendent of Agriculture and Curator of the Botanic Gardens at Darwin, N.T.

Mr. G. H. Clarke, who has been Botanist at the Waite Institute since 1936, relinquished his appointment on Apirl 30th.

Mr. A. R. Woodhill, Lecturer in Entomology, Sydney University, is studying in England under Professor Wigglesworth.

Mr. C. M. Donald, of the Waite Institute, and Mr. I. A. Watson, of Sydney University, were each awarded a Pawlett Scholarship early this year. Mr. Donald is studying grassland problems at the Welsh Plant Breeding Station, and Mr. Watson has made Minnesota University his headquarters.

Mr. G. W. Clarke has been appointed Lecturer in Biology at the Armidale Teachers' College, N.S.W.

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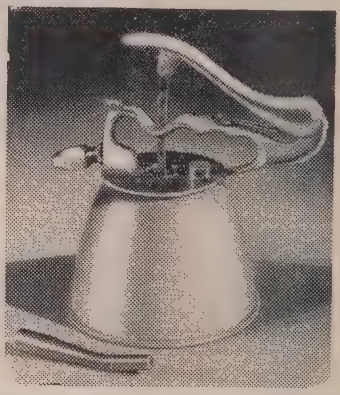

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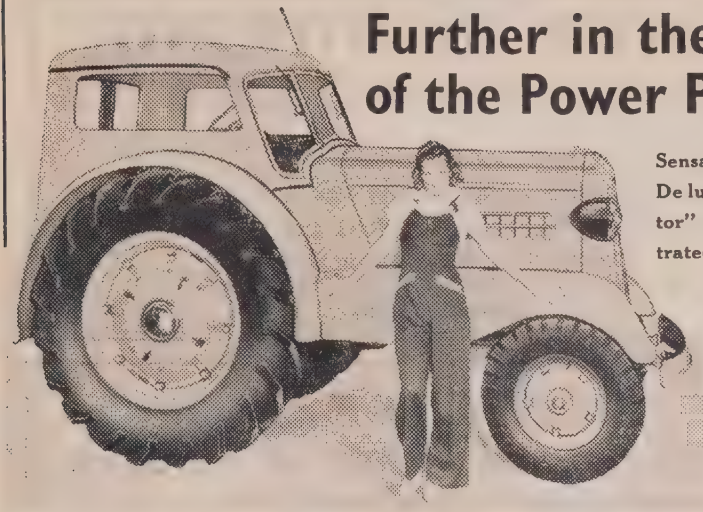

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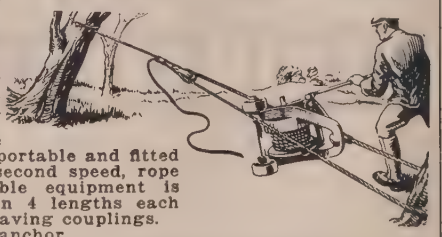

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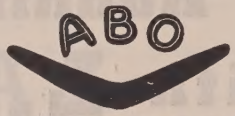


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